Miscellaneous Paper HL-93-3
July 1993

AD-A268 791

US Army Corps
of Engineers
Waterways Experiment
Station

Data Collection for Grand and White Lakes, Louisiana

by Howard A. Benson, Clara J. Coleman,
Joseph W. Parman
Hydraulics Laboratory

Approved For Public Release; Distribution Is Unlimited

Prepared for U.S. Army Engineer District, New Orleans

Miscellaneous Paper HL-93-3
July 1993

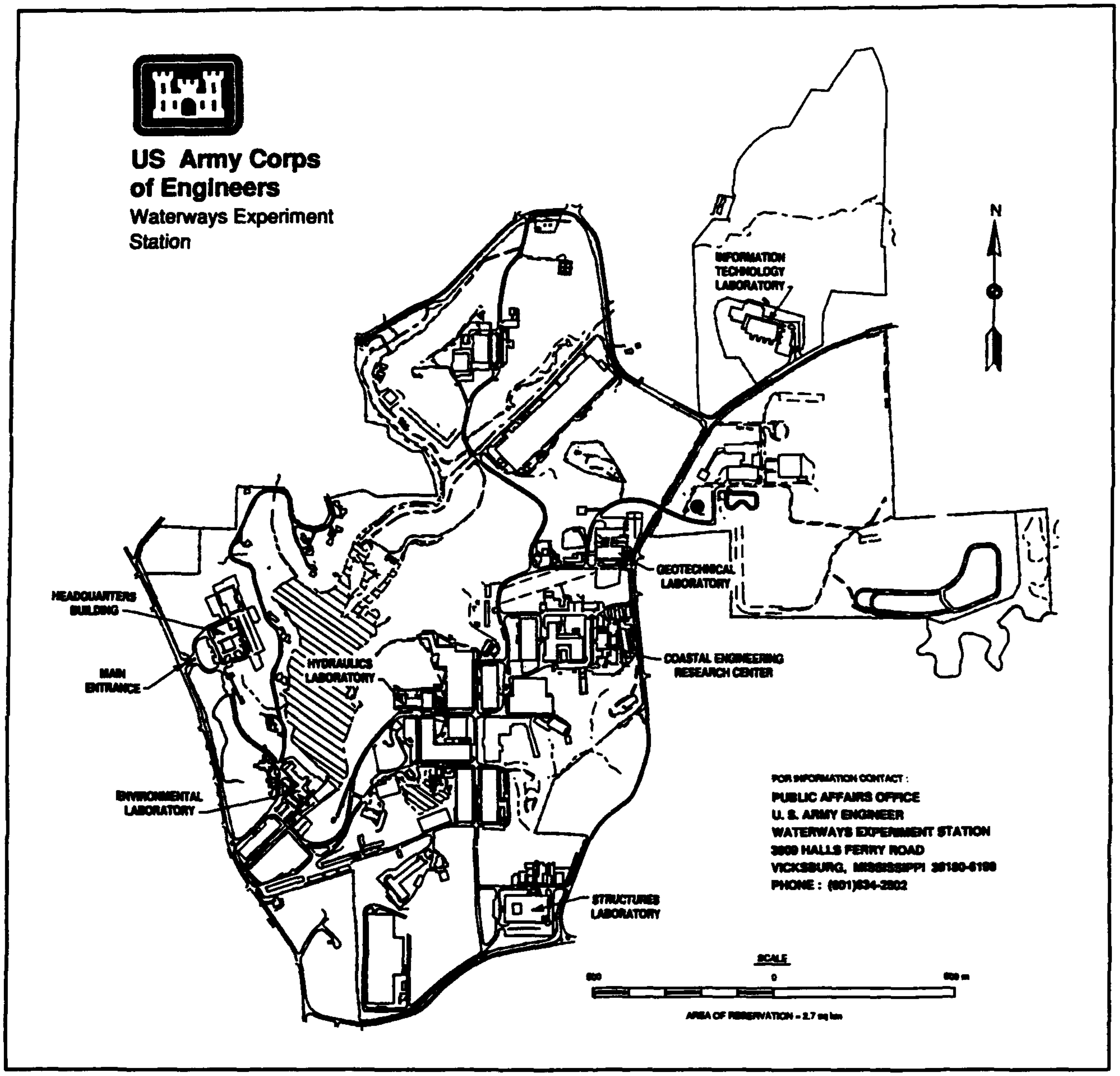
Data Collection for Grand and White Lakes, Louisiana

by Howard A. Benson, Clara J. Coleman,
Joseph W. Parman
Hydraulics Laboratory

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Engineer District, New Orleans
New Orleans, LA 70160-0267



Waterways Experiment Station Cataloging-in-Publication Data

Benson, Howard A.
Data collection for Grand and White Lakes, Louisiana / by Howard A. Benson, Clara J. Coleman, Joseph W. Parman ; prepared for U.S. Army Engineer District, New Orleans.
61 p. : ill. ; 28 cm. — (Miscellaneous paper ; HL-93-3)
1. Water use — Louisiana — Grand Lake Region. 2. Watershed management — Louisiana — White Lake Region. 3. Saltwater encroachment — Louisiana — Mathematical models. I. Coleman, Clara J. II. Parman, Joseph W. III. United States. Army. Corps of Engineers. New Orleans District. IV. U.S. Army Engineer Waterways Experiment Station. V. Title. VI. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; HL-93-3.
TA7 W34m no.HL-93-3

Contents

Preface

The work described in this report was performed by the Hydraulics Laboratory (HL) of the U.S. Army Engineer Waterways Experiment Station (WES) during November 1986 through December 1987 as a part of the Grand and White Lakes Investigation. The work for the Grand and White Lakes Study was conducted for the U.S. Army Engineer District, New Orleans (LMN), and managed by Mr. Stan Green, LMN.

This study was conducted under the direction of Messrs. Frank A. Herrmann, Jr., Director, HL; Richard A. Sager, Assistant Director, HL; William H. McAnally, Jr., Chief, Estuaries Division (ED), HL; and George M. Fisackerly, Chief, Estuarine Processes Branch (EPB), ED. Ms. Tamsen S. Dozier, formerly of Estuarine Simulation Branch, ED, served as the point of contact (POC) for all WES activities during the study until 31 August 1989. Mr. Joseph V. Letter, EPB, served as POC from then to the present. Mr. Burnell Thibadeaux served as POC for LMN.

The field data collection portion of the project study was managed by Mr. Fisackerly. The data collection program was designed by Messrs. Fisackerly, Howard A. Benson, Allen M. Teeter, and Joseph W. Parman, and Ms. Dozier, all of EPB, and executed under the direction of Ms. Dozier and Messrs. Benson and Parman. Other EPB personnel participating in the data collection were Messrs. Samuel E. Varnell, Larry G. Caviness, Billy H. Moore (retired), James T. Hilbun (retired), and Julian M. Savage, formerly of EPB. Data reduction was performed by Mmes. Dozier and Clara J. Coleman, EPB, and Messrs. Benson, Parman, and Letter. Laboratory analyses of water samples were performed by Mr. Caviness. This report was prepared by Messrs. Benson and Parman and Ms. Coleman.

Dr. Robert W. Whalin was Director of WES during the publication of this report. COL Leonard G. Hassell, EN, was Commander.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurements used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
feet	0.3048	meters
inches	2.54	centimeters
knots (international)	0.514444	meters per second
miles (U.S. statute)	1.609344	kilometers
square miles	2.589988	square kilometers
Fahrenheit degrees	5/9	Celsius degrees or kelvins[1]

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

1 Introduction

Project Description

Grand and White Lakes are located in southwest Louisiana. The study area covers portions of four parishes, Vermilion, Cameron, Acadia, and Jefferson Davis (Figure 1) and is bounded by the Calcasieu Ship Channel and Calcasieu Lake on the west, Vermilion Bay on the east, the Gulf of Mexico to the south, and a line between the cities of Lake Charles and Lafayette on the north.

The study area covers approximately 2000 square miles[1] and is rich in natural resources: oil, gas, fish, shrimp, wildlife, and fowl. The area is used by numerous widely divergent interests: farmers (crawfish and rice being the two major crops), cattlemen, fishermen, shrimpers, hunters, trappers, navigation interests, and fish and wildlife interests. Each of these groups has different and often conflicting water use requirements. Management of the water levels and salinities balances the needs between these varying groups.

The Grand and White Lakes area is composed mostly of low-lying marshes, prairies, lakes, bayous, and canals (both natural and manmade). The Gulf Intracoastal Waterway (GIWW) reach between the Calcasieu River on the west and the Vermilion River on the east is the primary inland navigation route within the project area.

Three locks and two control structures provide for navigation, flood control, salinity intrusion, and fresh water for rice irrigation. Other beneficial uses of the control structures are for enhancement of fish and wildlife productivity, and erosion protection. Vermilion Lock was built in 1933 and replaced by the Leland Bowman Lock in 1985. Catfish Point Control Structure and Calcasieu Lock were completed in 1950, Schooner Bayou Control Structure in 1951, and Freshwater Bayou Lock in 1968 (Figure 1). The Freshwater Bayou project provided a navigation channel from the GIWW to the Gulf of Mexico.

---

[1] A table of factors for converting non-SI units of measurement to SI units is found on page v.

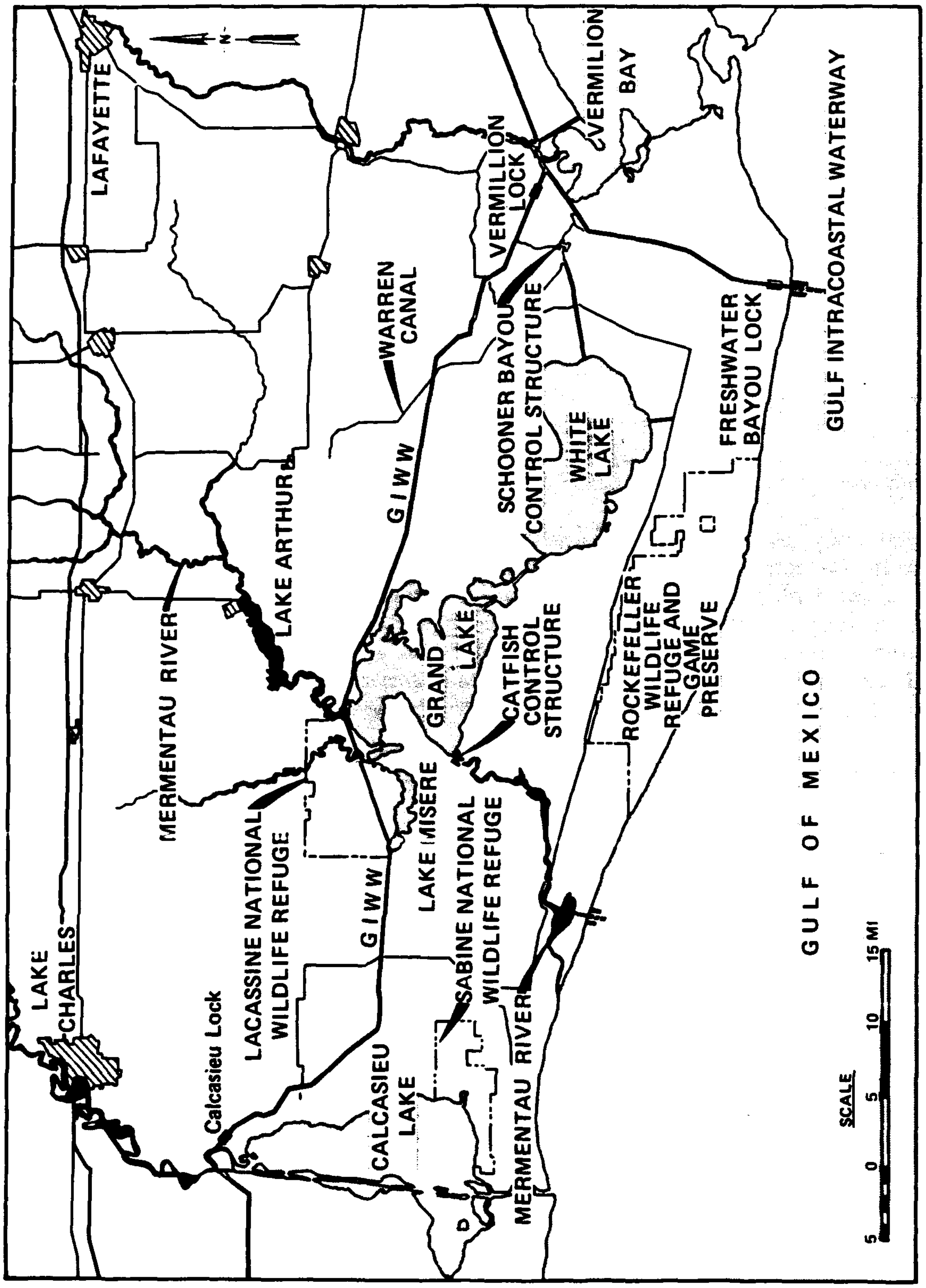


Figure 1. Grand and White Lakes vicinity map

The Mermentau River is formed by the confluence of Bayou des Cannes, Nezpique, and Plaquemine Brule. The river goes through Lake Arthur before entering Grand Lake at the GIWW. It passes through Catfish Point Control Structure to the Gulf. Other major tributaries are Bayous Queue de Tortue and Lacassine. The Mermentau River is subject to tidal action below the Catfish Point Control Structure. The watershed, because of its low relief, especially in the prairie and marsh areas, is characterized by backwater flooding of agricultural lands, poor drainage, and saltwater intrusion.

Also located in the study area are the Lacassine and Sabine National Wildlife Refuges, and the Rockefeller State Wildlife Refuge and Game Preserve (Figure 1).

The climate of the area is semitropical in nature and influenced by the proximity of the Gulf of Mexico. Southerly winds produce afternoon thunderstorms in the summer, while winter storms are of the frontal type with heavy rains lasting the duration of the storm. The average annual temperature for the area is 68°F and average annual precipitation is about 58 inches.

The U.S. Army Engineer District, New Orleans (LMN), requested the Estuaries Division, Hydraulics Laboratory, of the Waterways Experiment Station (WES) to conduct a numerical model study of the Grand and White Lakes area and to provide LMN with predictions of the effects of several alternative plans on water levels, circulation patterns, and salinity intrusion in the Grand and White Lakes area. This study was to assist LMN in selecting a water management plan that will make the greatest contribution to the national economic development consistent with protecting the environment. The study objectives include: the increase of estuarine organisms and wildlife productivity; reduction of the duration and height of the peak stages presently experiencing; reduction of salinity levels in the water used for irrigation; and the reduction of shoreline erosion along the lakes.

Purpose

The purpose of the study was to predict the effects of several alternative plans on stages, circulation patterns, and salinity intrusion in the Grand and White Lakes area (Mermentau River Basin), Louisiana. The purpose of the field data collection program was to provide the necessary field data needed for the numerical modeling prediction efforts.

Scope

This report presents representative results of the field data collection program in the Grand and White Lakes area during November 1986 through December 1987. Measurements consisted of water level elevations at 10 locations; current velocity, current direction, temperature, and salinity at

11 locations; and point measurements of salinity at selected stations during equipment service trips.

This report describes the field investigation methods used to collect the data, shows representative results of the data reduction efforts, and describes the availability of the data for further use.

2 Data Collection Equipment and Program

Data were collected in the Grand and White Lakes area from November 1986 through December 1987. During this period, water level recorders and moored current meters were in place continuously. Additional salinity concentrations were collected during the equipment service trips. This data collection effort is described in the subsequent sections of this report.

Equipment and Deployment Locations

Water level measurements

During the Grand and White Lakes field investigation, ten water level recorders were deployed at locations shown in Figure 2, and identified as stations T10, T14, T16, T17, T18, T19, T20, T21, T21A, and T24. The water level elevations were monitored using Environmental Devices Corporation (ENDECO) Type 1029 SSM (Solid State Memory) Water Level Recorders and Fischer and Porter Company Type 1550 Punch Tape Water Level Recorders, as described in Appendix A; paragraphs 13-14 and 9-10, respectively. ENDECO 1029 SSM's were deployed at stations T14, T16, T17, T18, T19, and T21. The Fischer and Porter 1550's were deployed at stations T10, T20, T21A, and T24. The water level recorders at stations T21 and T21A are at the same location. This was done as a field comparison of the older mechanical recorder against a newer electronic recorder. The sampling interval of the 1029 SSM was 10 minutes for T18 and T19, and 30 minutes for the other recorders. The sampling interval on all the 1550's was 15 minutes. A typical deployment of a water level recorder is shown in Figure A11, Appendix A.

Current meter measurements

Current speed, current direction, temperature, and salinity measurements were recorded using ENDECO model 174 SSM current meters similar to that described in paragraphs 2-3 of Appendix A. Eleven current meters were deployed at locations shown in Figure 2. The locations were designated as

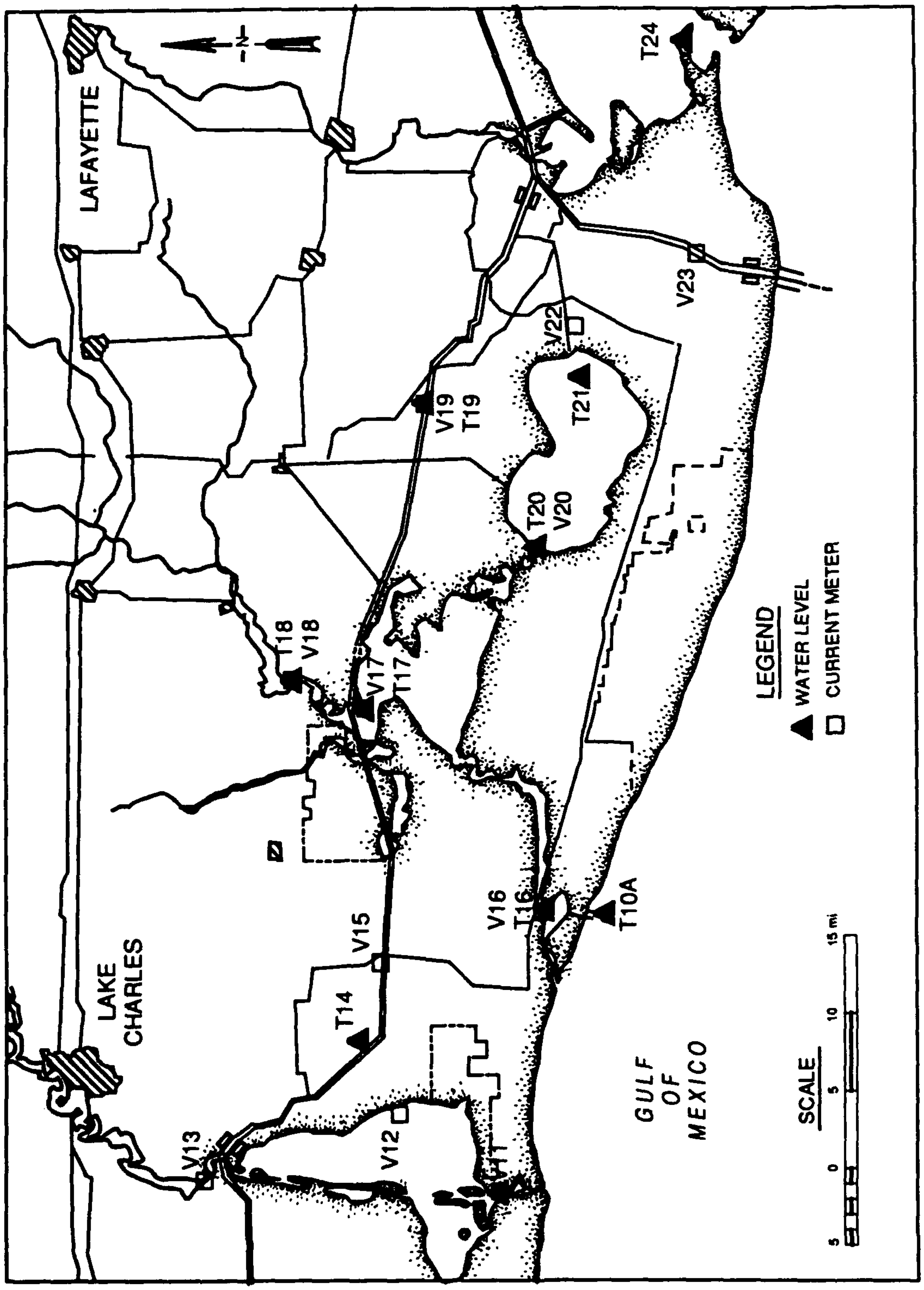


Figure 2. Water level and current meter monitoring stations

stations V11, V12, V13, V15, V16, V17, V18, V19, V20, V22, and V23. At each location the current meter was deployed at middepth as referenced to the location depth at low tide levels. The sampling interval of these recording current meters is 10 min. A typical current meter deployment is shown in Figure A4, Appendix A.

Salinity measurements

Salinity measurements during equipment service trips were obtained using an Aanderaa model 2975 hand-held portable salinity sensor with a model 3012 display unit.

Equipment Service Procedures

At about monthly intervals all the equipment was cleaned and checked for proper operation, new batteries installed, stored data retrieved and new recording media installed where applicable. Due to the availability of spare meters, current meters were swapped out and returned to the land base nightly for data reduction. The meters were returned to alternate locations the next day.

Long-term Equipment Service Problems

Some data loss is unavoidable in long-term data collection. Tables 1 and 3 present a deployment time history of all the equipment locations during the study period. One of the major problems is destruction of submerged moored current meters and water level recorders by commercial fishing nets, local fishermen, barge and ship traffic, and vandalism. The Calcasieu River, Vermilion Bay, and the GIWW are very high traffic areas. The deployment locations were marked with surface floats, mounted on channel markers, reported to the USCG, and published in the Local Notice to Mariners. Local interest groups were also informed of the presence of equipment in the area; however, several current meters and water level recorders were lost despite these precautions.

As with all long-term deployments, unattended equipment can become susceptible to bio-fouling and other mechanical problems. Suspended sediment content in the entire water column was very high; therefore, the abrasive sediment had the potential to quickly damage meter bearings.

Weather conditions in the Grand and White Lakes area (e.g., fog, wind, or storms) sometimes prevented scheduled maintenance trips to service deployed meters and recorders and to retrieve data. When servicing was delayed, loss of battery power and meter malfunction caused loss of data at some locations.

3 Data Presentation

The data described here are presented in several different formats. Due to the magnitude of data collected for the Grand and White Lakes study, only summary tables, sample printouts, and sample plots are shown. The data, collected from November 1986 through December 1987, is stored on floppy disks at CEWES-HE and at LMN.

Water Level Measurements

Table 1 shows the list of available water level data collected for each station during the data collection program. A beginning and ending date for each data record is shown along with some comments regarding the station. Table 2 is a sample printout of water level data collected at 30 minute sampling for station T16. The data was recorded on 12/4/86 from 0030-1900 CST.

Time history plots of the water surface data for stations T10, T14, T16, T17, T18, T19, T20, T21, T21A, and T24 are presented in Plates 1-10, respectively. All the plots are for a one week period, December 1-7, 1986 with the exception of T10 which is August 7-13, 1987. Station T10 was not in operation during December 1986. Datum planes for the gages are arbitrary.

Stations near the Gulf with tidal influence show normal water-surface fluctuations of 2-4 ft, while other stations in the lakes and GIWW remain at a rather constant level.

Current Meter Measurements

Table 3 presents a list of available current meter data collected at each station during the data collection program. A beginning and ending date for each data record is shown along with some comments regarding the station. Table 4 is a sample printout of current meter data as collected at 10 minute sampling intervals for station V11. The data were recorded on 12/1/86 from 1130-1730 CST.

A few representative time history plots of the current speed and salinity data for stations V11, V13, V16, V20, V22, and V23 are presented in Plates 11-16, respectively. All the plots are for a one week period during the month of December, 1986. The current speed is in fps and ebb and flood directions noted. At some locations the predominant flow directions are labeled on the plots in place of ebb and flood.

Locations such as V11 (Plate 11), showed strong ebb and flood current speeds with corresponding fluctuations in salinity values, whereas stations such as V20 (Plate 14), showed weaker current speeds and low salinity.

Salinity Measurements

Representative salinity measurements at 34 stations are presented in Table 5 and were collected during the December 10-12, 1986 equipment service trip. Locations of these stations are shown in Figure 3. Table 5 lists the date, the station, time, depth of sample, and the salinity in ppt.

Mermentau River Discharge

Plate 17 represents the calculated discharge from the Mermentau River Basin for the period November 1, 1986 through January 31, 1988. The discharge in cfs, was computed for the Mermentau River Basin, based on the rainfall runoff model, HEC-1.

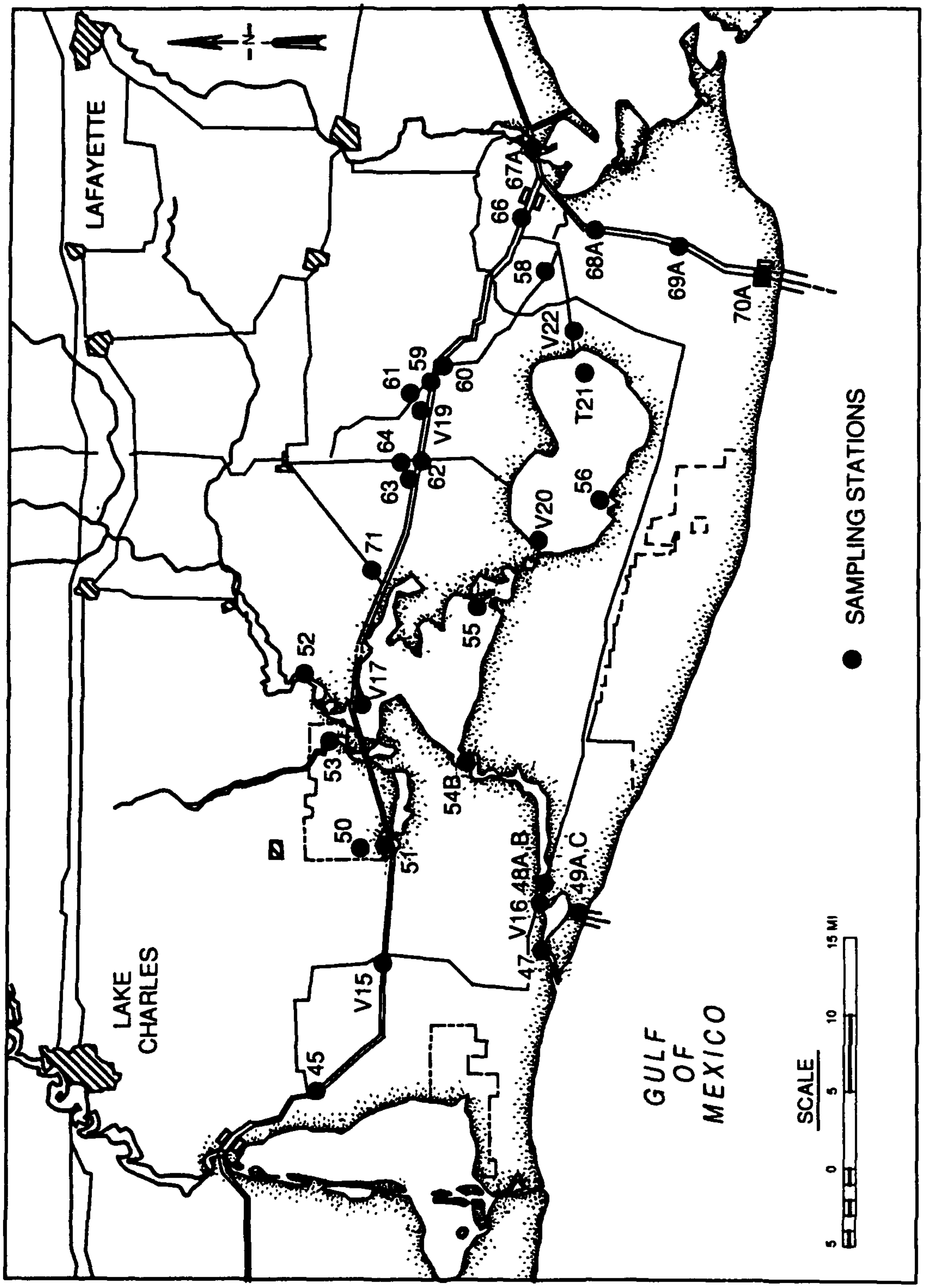


Figure 3. Salinity measurement locations, December 10-12, 1986

4 Summary

The data collected as described herein provided essential information to establish the geometry, boundary conditions, and verification data needed for the numerical modeling prediction efforts.

Table 1
List of Available Water Level Recorder Data

Station No.	Data Period: Beginning Date	Data Period: Ending Date	Comments
T10	4/21/87	4/27/87	
	4/27/87	7/27/87	Gage malfunction - No data
	7/27/87	9/16/87	
	9/16/87	1/06/88	Data ended 12/15/87 End of station
T14	11/13/86	12/10/86	
	12/10/86	2/24/87	
	2/24/87	4/22/87	
	4/22/87	6/24/87	
	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/06/88	End of station
T16	11/13/86	12/09/86	
	12/10/86	2/25/87	Gage malfunction - No data
	2/25/87	4/21/87	
	4/21/87	7/27/87	
	7/27/87	8/02/87	
	8/02/87	1/06/88	Gage malfunction - No data End of station
T17	11/14/86	12/11/86	
	12/11/86	2/24/87	
	2/24/87	4/22/87	
	4/22/87	6/24/87	
	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/06/88	End of station
T18	11/14/86	12/11/86	
	12/11/86		Gage vandalized - Not replaced End of station
T19	11/16/86	12/22/86	
	12/11/86		Gage vandalized - Not replaced End of station
T20	11/15/86	12/11/86	

(Continued)

Table 1 (Concluded)

Station No.	Data Period		Comments
	Beginning Date	Ending Date	
T20 (Cont)	12/11/86	2/23/87	
	2/23/87	4/24/87	
	4/24/87	6/24/87	
	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/07/88	Data ended 12/12/87 End of station
T21	11/15/86	12/11/86	
	12/11/86	2/23/87	
	2/23/87	4/23/87	
	4/23/87	6/23/87	
	6/23/87	7/28/87	
	7/28/87	9/14/87	
	9/14/87	1/07/88	End of station
T21A	11/15/86	12/11/86	
	12/11/86	2/23/87	
	2/23/87	4/23/87	
	4/23/87	6/23/87	
	6/23/87	7/28/87	
	7/28/87	9/14/87	
	9/14/87	1/07/88	Data ended 12/09/87 End of station
T24	11/15/86	12/12/86	
	12/12/86	2/23/87	
	2/23/87	4/23/87	
	4/23/87	6/23/87	
	6/23/87	7/29/87	
	7/29/87		Gage destroyed - Not replaced End of station

Table 2
Sample Printout of Water Level Recorder Data for Station T16

Grand and White Lakes

Station T16 - Lower Mermentau River
ENDECO Type 1029 Water Level Recorder
Datum Offset Applied: .000 (Feet)
Serial Number: 10290031

Date mm/dd/yy	Time (CST) hh:mm	Depth ft*
12/04/86	00:30	1.994
12/04/86	01:00	2.017
12/04/86	01:30	2.187
12/04/86	02:00	2.333
12/04/86	02:30	2.503
12/04/86	03:00	2.693
12/04/86	03:30	2.912
12/04/86	04:00	3.185
12/04/86	04:30	3.387
12/04/86	05:00	3.608
12/04/86	05:30	3.830
12/04/86	06:00	4.057
12/04/86	06:30	4.266
12/04/86	07:00	4.422
12/04/86	07:30	4.500
12/04/86	08:00	4.604
12/04/86	08:30	4.682
12/04/86	09:00	4.721
12/04/86	09:30	4.722
12/04/86	10:00	4.723
12/04/86	10:30	4.696
12/04/86	11:00	4.622
12/04/86	11:30	4.510
12/04/86	12:00	4.391
12/04/86	12:30	4.280
12/04/86	13:00	4.180
12/04/86	13:30	4.119
12/04/86	14:00	4.050
12/04/86	14:30	4.130
12/04/86	15:00	4.157
12/04/86	15:30	4.168
12/04/86	16:00	4.201
12/04/86	16:30	4.229
12/04/86	17:00	4.187
12/04/86	17:30	4.122
12/04/86	18:00	4.058
12/04/86	18:30	3.972
12/04/86	19:00	3.906

* datum is arbitrary.

Table 3
List of Available Cur‹ent Meter Data

Station No.	Data Period: Beginning Date	Data Period: Ending Date	Comments
V11	11/13/86	2/25/87	
	2/25/87	4/21/87	
	4/21/87	7/27/87	Meter Lost - Not replaced End of station
V12	11/13/86	3/05/87	
	3/05/87	4/21/87	
	4/21/87	7/27/87	
	7/27/87	9/16/87	
	9/16/87	1/06/88	End of station
V13	11/14/86	12/09/86	
	12/09/86	2/25/87	Meter Lost - Not replaced End of station
V15	11/13/86	12/10/86	
	12/10/86	2/25/87	Meter destroyed - Not replace End of station
V16	11/13/86	12/10/86	
	12/10/86	2/25/87	
	2/25/87	4/21/87	
	4/21/87	7/27/87	
	7/27/87	9/16/87	
	9/16/87	1/06/88	End of station
V17	11/14/86	12/11/86	
	12/11/86	2/24/87	
	2/24/87	4/22/87	
	4/22/87	6/24/87	
	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/07/88	End of station
V18	11/14/86	12/11/86	
	12/11/86	2/25/87	
	2/25/87	4/22/87	
	4/22/87	6/24/87	

(Continued)

Table 3 (Concluded)			
Station No.	Data Period		Comments
	Beginning Date	Ending Date	
V18 (Cont)	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/06/88	Meter destroyed - End of station
V19	11/16/86	12/11/86	
	12/11/86	2/24/87	
	2/24/87	4/22/87	
	4/22/87	6/24/87	
	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/07/88	End of station
V20	11/15/86	12/11/86	
	12/11/86	2/23/87	
	2/23/87	4/24/87	
	4/24/87	6/24/87	
	6/24/87	7/28/87	
	7/28/87	9/15/87	
	9/15/87	1/07/88	End of station
V22	11/15/86	12/11/86	
	12/11/86	2/23/87	Meter destroyed - Not replaced End of station
V23	11/15/86	12/12/86	
	12/12/86	2/23/87	
	2/23/87	4/23/87	
	4/23/87	6/23/87	
	6/23/87	7/29/87	
	7/29/87	9/16/87	
	9/16/87	1/07/88	End of station

Table 4
Sample Printout of Current Meter Data for Station V11

Grand and White Lakes

Station V11 - Calcasieu Ship Channel (CM57)
ENDECO Type 174SSM Solid State Current Meter
Serial Number: 174SSM0023
Date: MON 1-DEC-1986 Julian date: 335

Time (CST) hh:mm:ss	Current Speed knots	Current Direction deg*	Temperature °C	Conductivity mmhos/cm	Meter Depth ft	Salinity ppt
11:30:00	.93	182	15.33	8.37	11.13	5.79
11:40:00	.89	175	15.35	8.41	11.31	5.84
11:50:00	.96	176	15.37	8.06	11.40	5.62
12:00:00	.89	187	15.35	8.28	11.13	5.72
12:10:00	.65	186	15.43	8.34	11.13	5.84
12:20:00	.26	180	15.45	9.44	11.48	6.36
12:30:00	.23	180	15.43	10.44	11.40	7.55
12:40:00	.16	185	15.43	9.63	11.21	7.03
12:50:00	.16	181	15.45	9.31	11.40	6.57
13:00:00	.02	188	15.45	9.53	11.40	6.67
13:10:00	.00	359	15.47	9.13	11.48	6.46
13:20:00	.05	354	15.47	9.28	11.48	6.37
13:30:00	.30	358	15.47	9.53	11.48	6.56
13:40:00	.41	358	15.39	10.35	11.48	7.20
13:50:00	.42	5	15.43	10.91	11.48	7.89
14:00:00	.62	1	15.35	11.16	11.48	7.91
14:10:00	.69	359	15.35	11.47	11.40	8.48
14:20:00	.75	359	15.37	11.41	11.48	7.97
14:30:00	.72	0	15.41	10.97	11.40	7.97
14:40:00	.79	359	15.49	10.94	11.40	7.75
14:50:00	1.00	357	15.53	10.88	11.48	7.71
15:00:00	1.04	356	15.45	11.50	11.48	8.16
15:10:00	.97	357	15.43	12.35	11.48	8.82
15:20:00	.82	356	15.39	13.19	11.48	9.48
15:30:00	.73	356	15.47	13.54	11.40	9.75
15:40:00	1.11	0	15.61	13.51	11.67	9.52
15:50:00	.61	359	15.98	17.42	11.83	11.96
16:00:00	.59	355	16.43	21.64	11.56	16.25
16:10:00	.53	356	16.72	24.27	11.67	18.02
16:20:00	.81	357	16.72	23.96	11.83	17.10
16:30:00	.77	358	16.88	25.43	11.93	19.86
16:40:00	.96	356	16.90	25.43	11.93	17.82
16:50:00	1.04	355	16.94	25.58	11.93	18.26
17:00:00	.82	357	17.33	28.68	11.93	21.73
17:10:00	.76	358	17.39	29.28	11.93	22.06
17:20:00	.89	1	17.25	28.09	11.93	20.64
17:30:00	.72	359	17.25	28.06	11.93	20.48

* deg = direction from true north from which the current is flowing.

Table 5
Salinity Measurements
12-10/12-86 Data Collection

Date	Station	Time cst	Depth ft	Salinity ppt
12/10/86	V16	0945	4.5	1.9
	48A	1051	3.0	1.9
			7.3	1.9
			12.5	1.9
	48B	1057	3.0	1.7
			6.0	1.7
	47	1035	2.0	2.8
			4.0	4.0
	49A	1010	3.0	4.5
			7.5	11.0
			13.0	33.7
	49C	1015	3.0	5.4
			8.5	20.7
			15.0	36.0
	54B	1145	3.0	1.6
			9.0	1.7
			16.0	1.7
	V15	1420	3.0	0.8
			7.5	0.8
			13.0	0.9
	45	1504	3.0	1.9
			7.5	2.0
			13.0	1.9
	50	1550	3.0	0.8
			7.0	0.8
	51	1555	3.0	0.9
			8.0	1.1
			14.0	0.9
12/11/86	V17	0815	4.0	0.8
	55	0920	2.0	0.8
			4.0	0.8

(Sheet 1 of 3)

Table 5 (Continued)

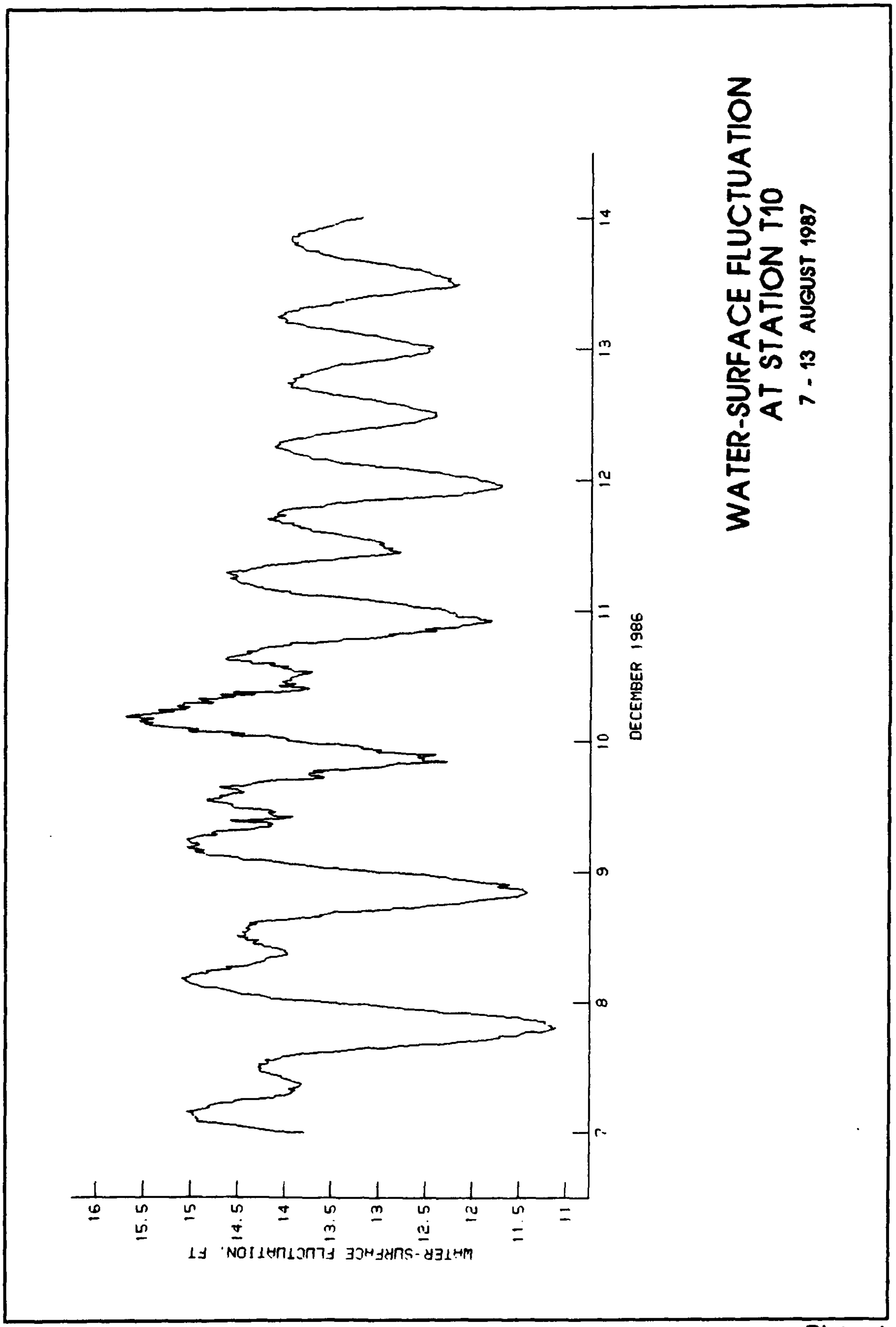
Date	Station	Time cst	Depth ft	Salinity ppt
12/11/86 (Cont)	V20	1004	2.0	1.4
			4.5	1.4
	56	1040	3.0	2.8
	T21	1122	4.0	3.1
	V22	1135	3.0	3.0
	58	1144	3.0	1.9
	59	1234	8.3	0.9
			14.5	0.8
	60	1240	3.0	0.8
	61	1250	4.0	0.8
	V19	1255	3.0	0.8
			15.0	0.8
	64	1345	2.0	0.8
			4.0	0.8
	62	1352	3.0	0.8
			6.0	0.8
	63	1358	3.0	0.8
			8.4	0.8
			14.8	0.8
	52B	1521	3.0	0.8
			13.0	0.8
			22.0	0.8
	53A	1444	3.0	0.8
			5.5	0.8
12/12/86	66	0940	3.0	1.1
			8.5	1.1
			15.0	1.1
	65	1039	3.0	3.0
			8.3	3.0
			14.5	3.0
	70A	1125	3.0	13.4
			6.0	13.4
			10.0	13.4

(Sheet 2 of 3)

Table 5 (Concluded)

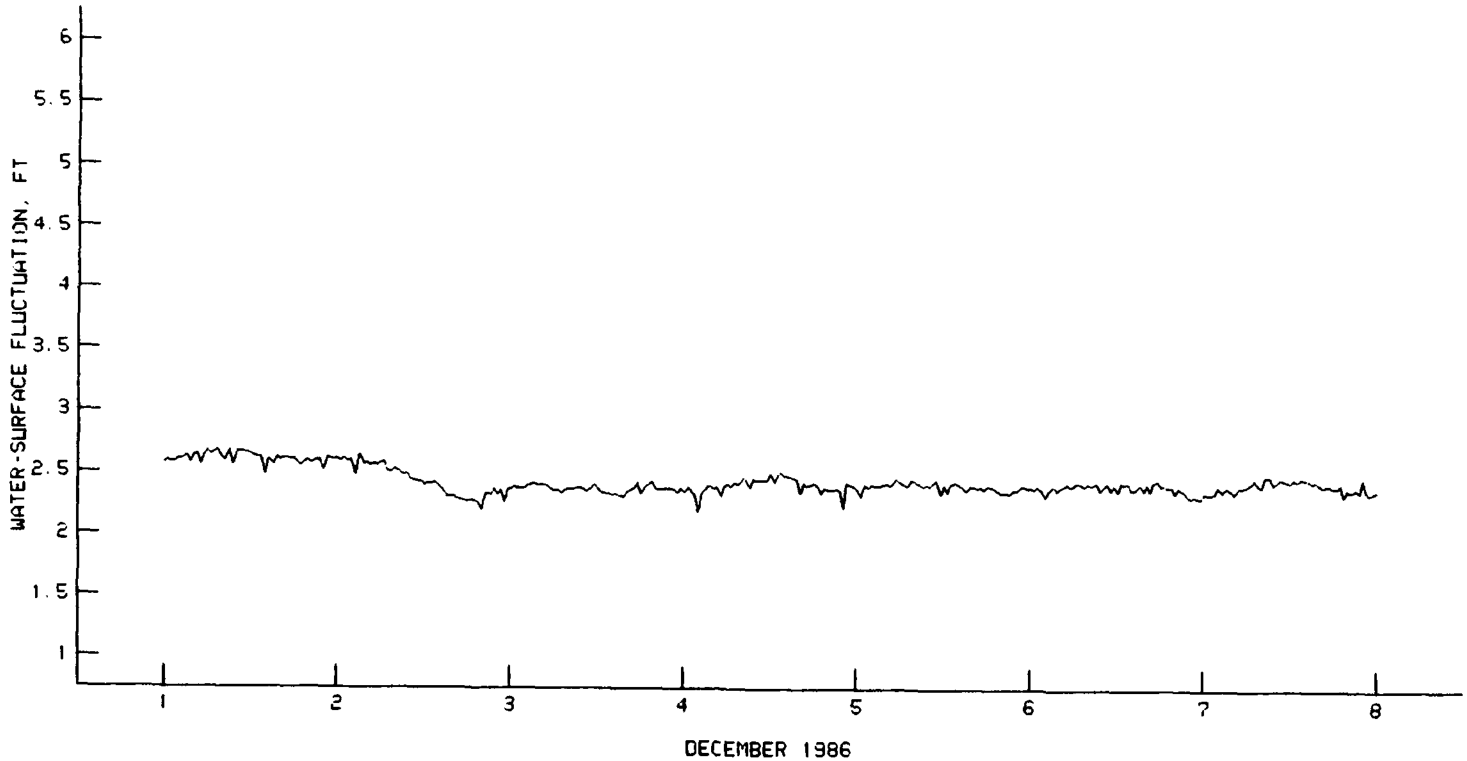
Date	Station	Time cst	Depth ft	Salinity ppt
12/12/86 (Cont)	69A	1154	3.0	10.6
			6.0	10.6
			10.0	10.6
	68A	1222	3.0	9.5
			6.5	9.5
			11.0	8.4
	67A	1250	3.0	2.2
			7.0	2.7
			12.0	2.7
	71	1545	3.0	11.0

(Sheet 3 of 3)



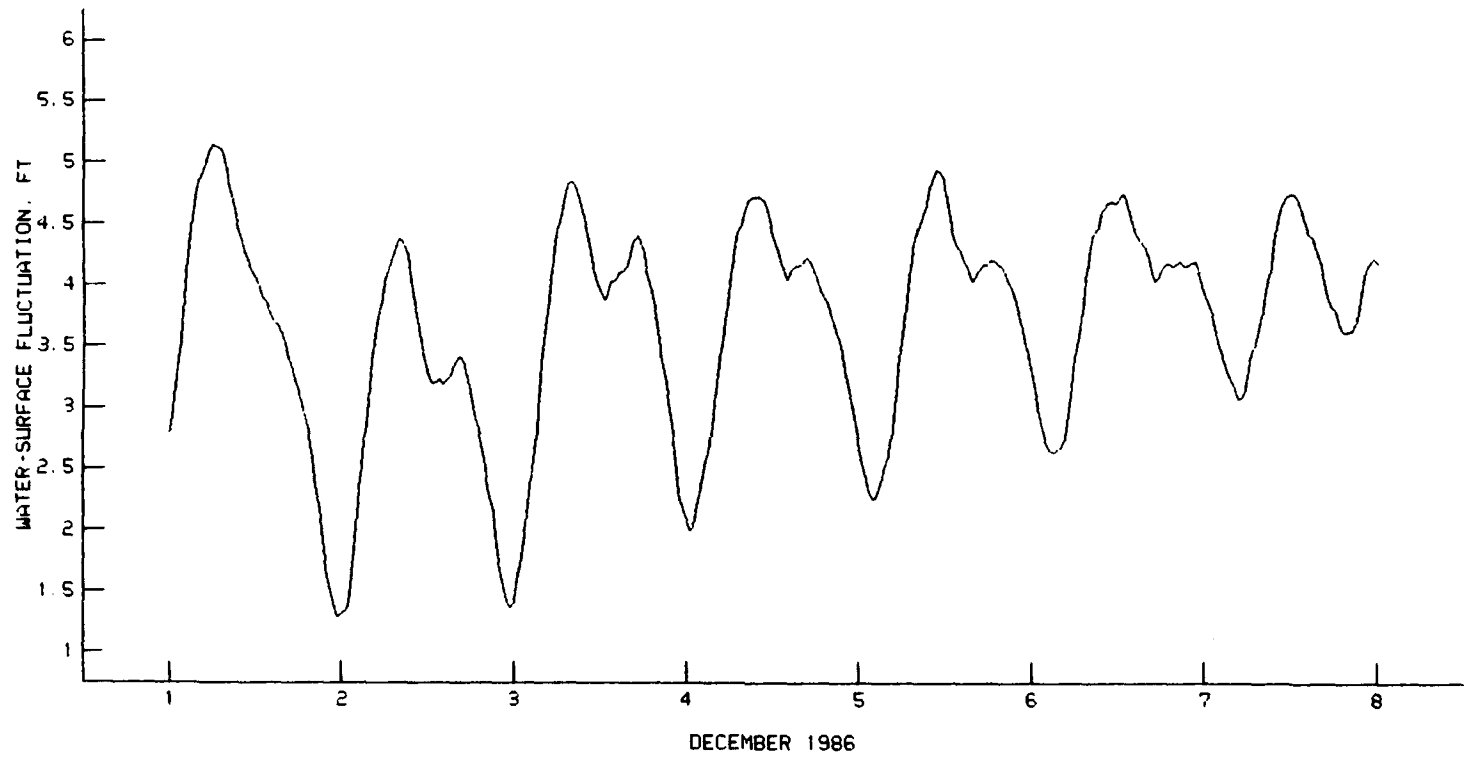
WATER-SURFACE FLUCTUATION
AT STATION T10
7 - 13 AUGUST 1987
WATER-SURFACE FLUCTUATION, FT
16
15.5
15
14.5
14
13.5
13
12.5
12
11.5
11
7
8
9
10
11
12
13
14
DECEMBER 1986

Plate 1

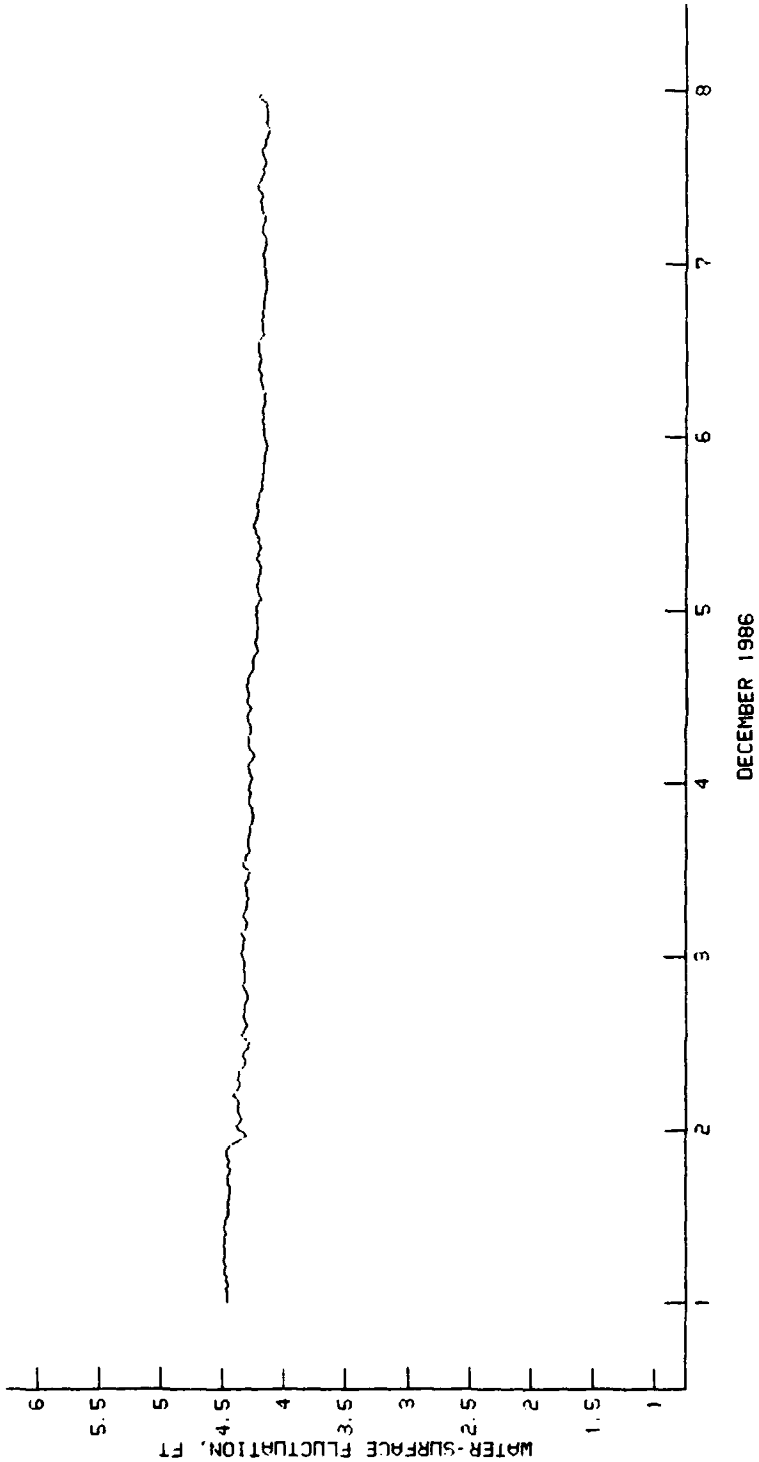


WATER-SURFACE FLUCTUATION
AT STATION T14
1 - 7 DECEMBER 1986

Plate 2



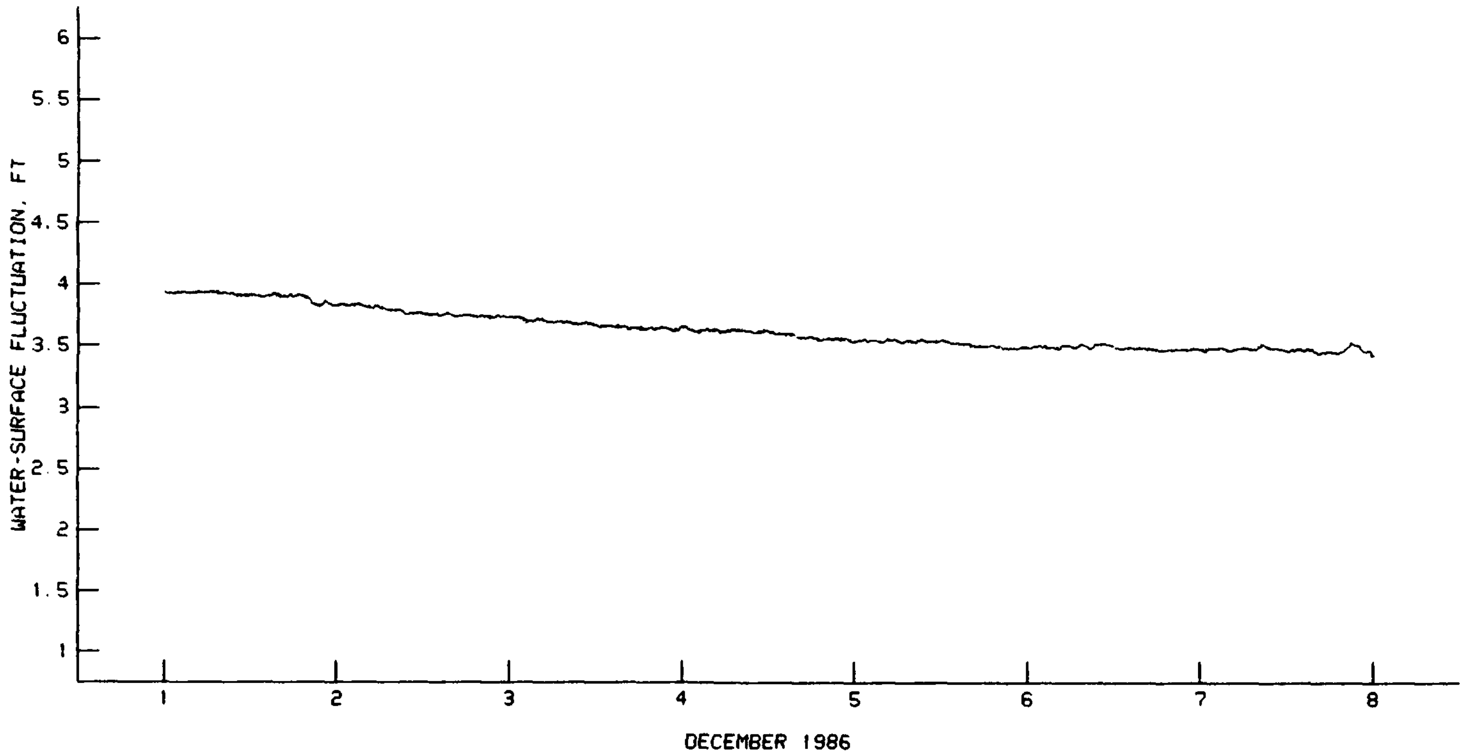
WATER-SURFACE FLUCTUATION
AT STATION T16
1 - 7 DECEMBER 1986



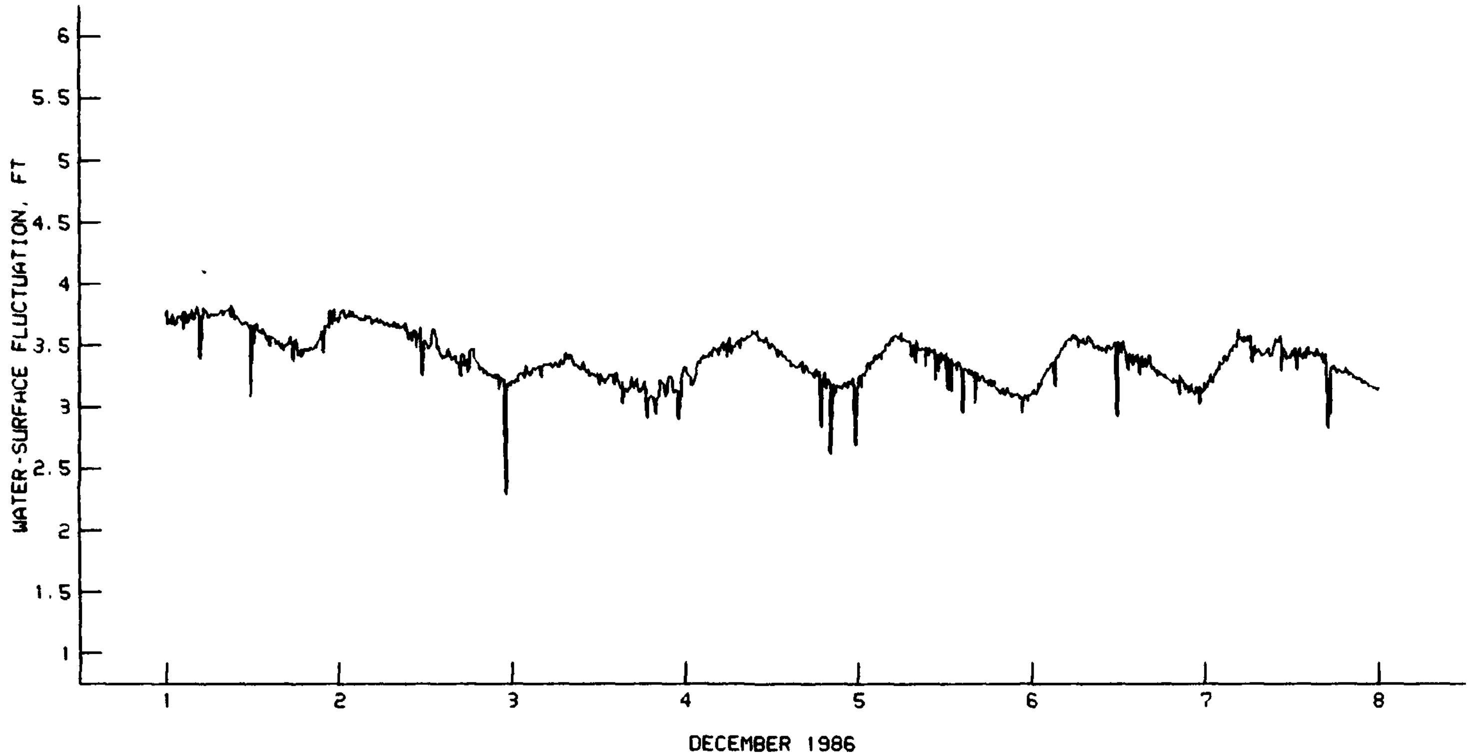
WATER-SURFACE FLUCTUATION AT STATION T17

1 - 7 DECEMBER 1986

Plate 4

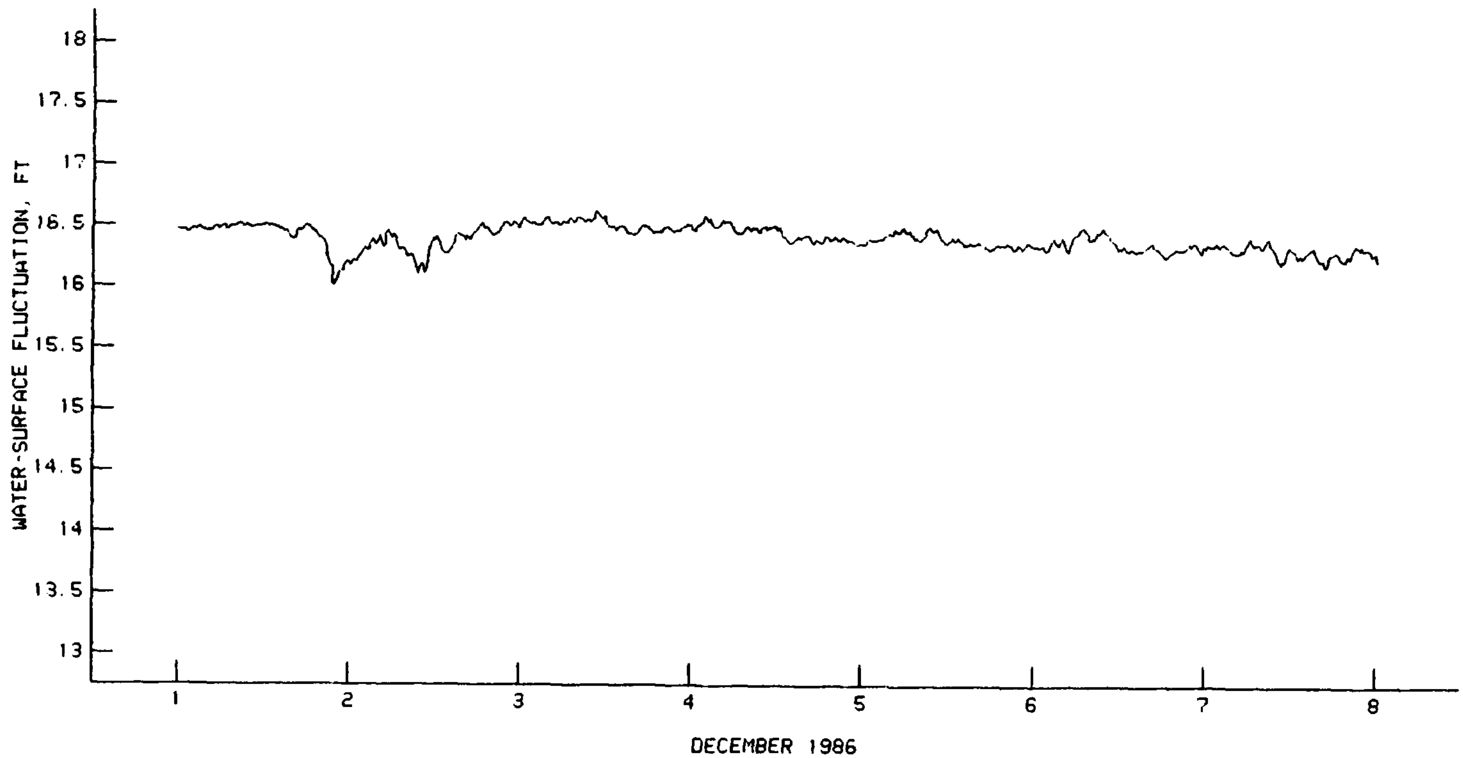


WATER-SURFACE FLUCTUATION
AT STATION T18
1 - 7 DECEMBER 1986

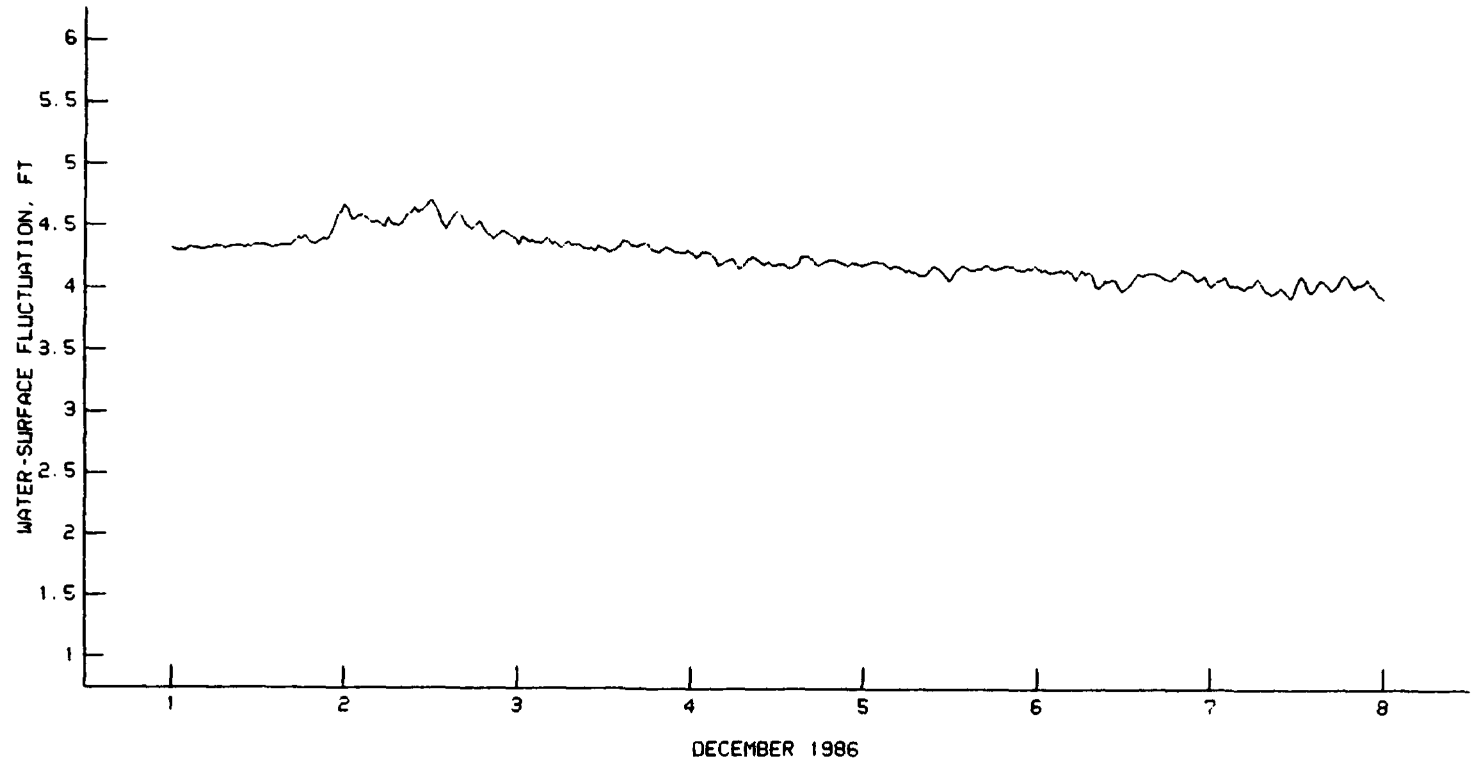


WATER-SURFACE FLUCTUATION
AT STATION T19
1 - 7 DECEMBER 1986

Plate 6



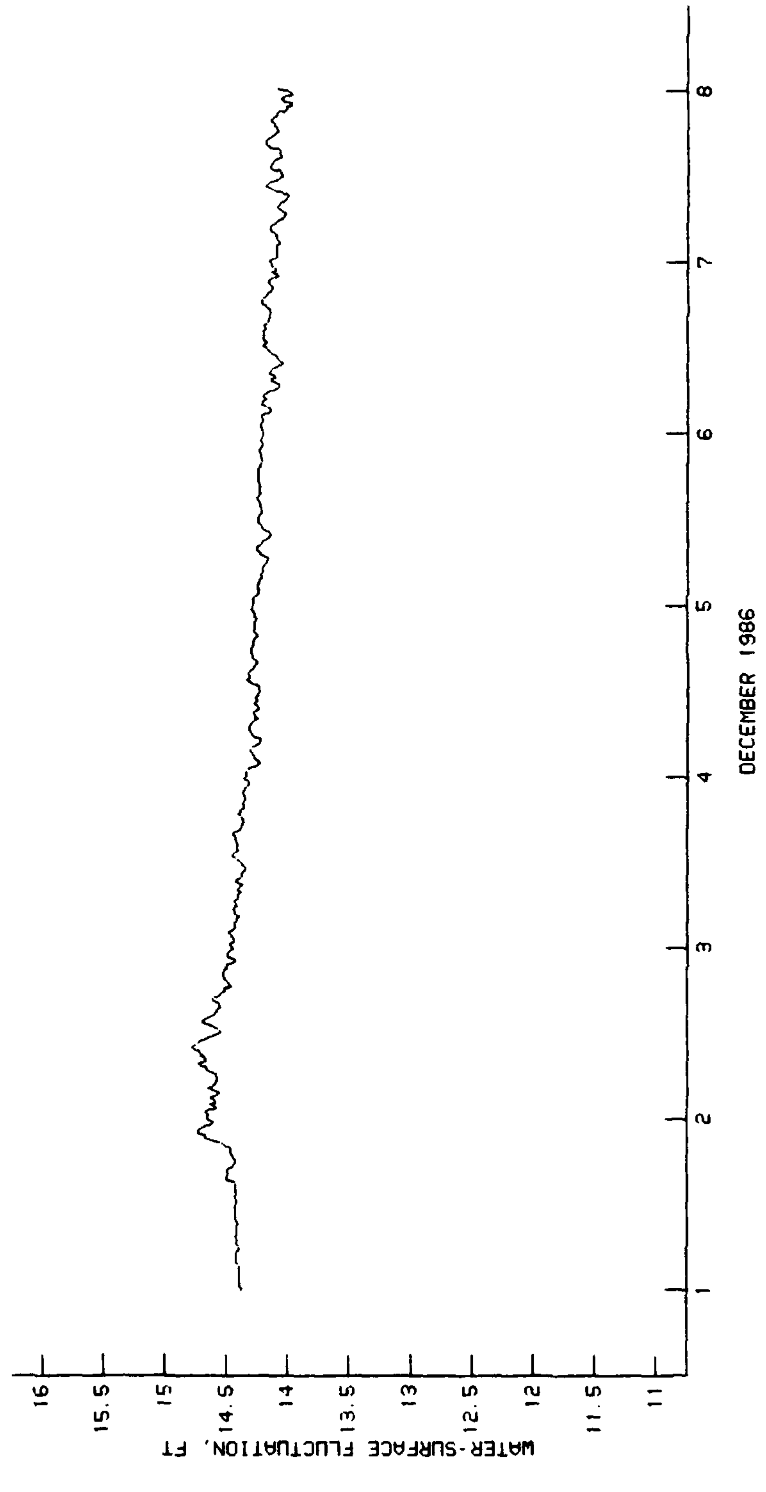
WATER-SURFACE FLUCTUATION
AT STATION T20
1 - 7 DECEMBER 1986



WATER-SURFACE FLUCTUATION AT STATION T21

1 - 7 DECEMBER 1986

Plate 8



WATER-SURFACE FLUCTUATION
AT STATION T21A
1 - 7 DECEMBER 1986

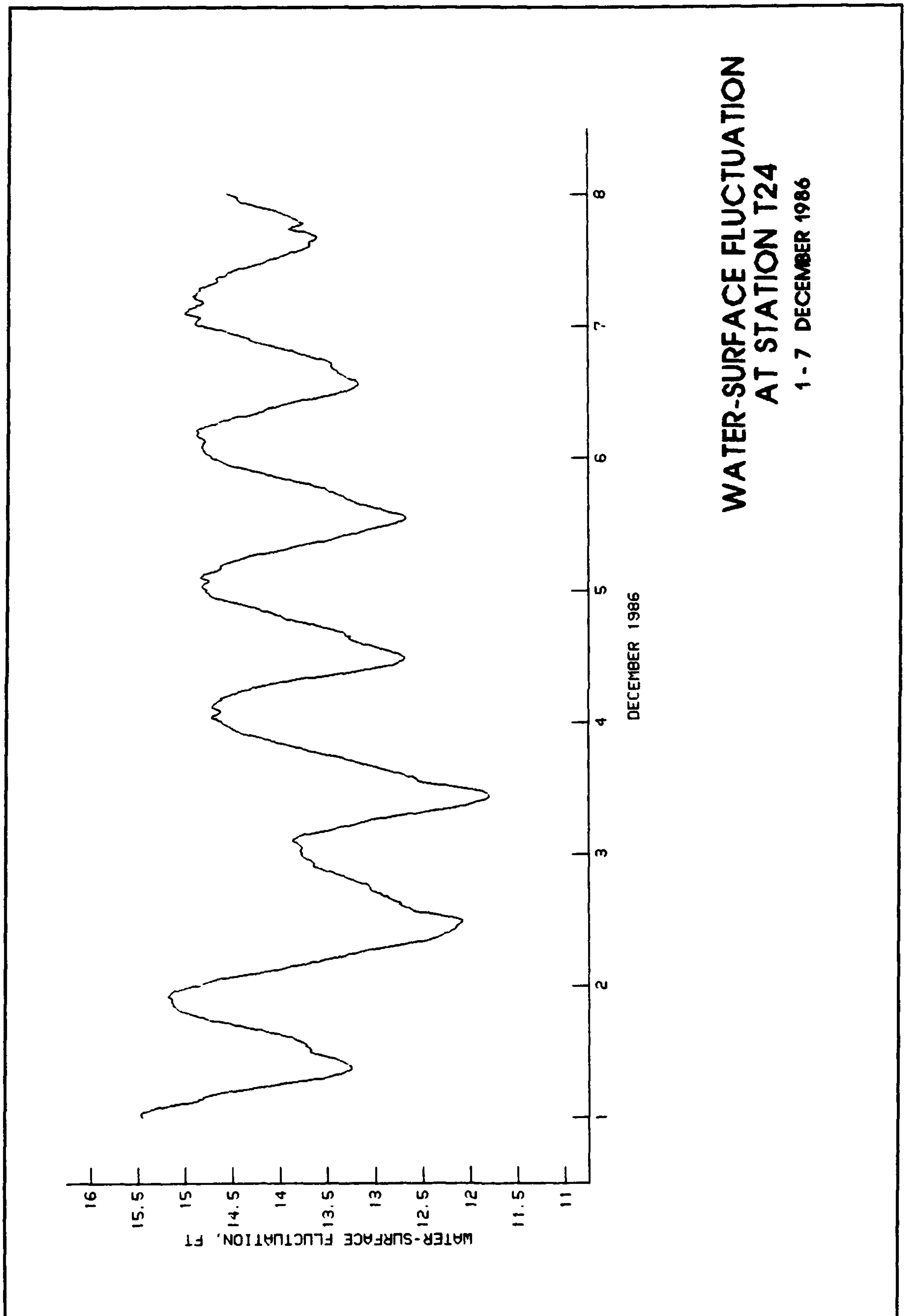
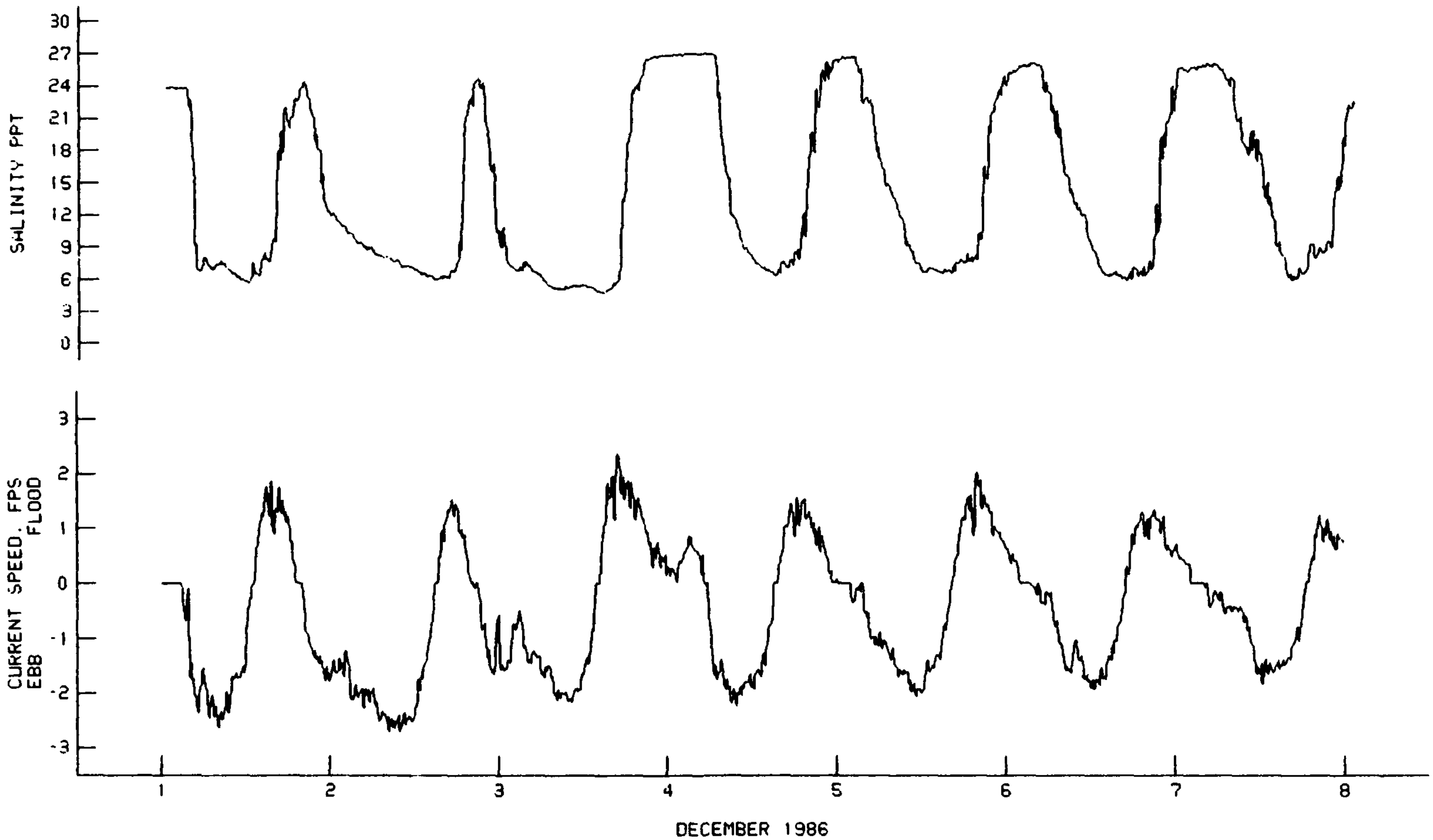

WATER-SURFACE FLUCTUATION
AT STATION T24
1 - 7 DECEMBER 1986
WATER-SURFACE FLUCTUATION, FT
16
15.5
15
14.5
14
13.5
13
12.5
12
11.5
11
1
2
3
4
5
6
7
8
DECEMBER 1986

Plate 10



CURRENT SPEED AND SALINITY
STATION V11
1 - 7 DECEMBER 1986

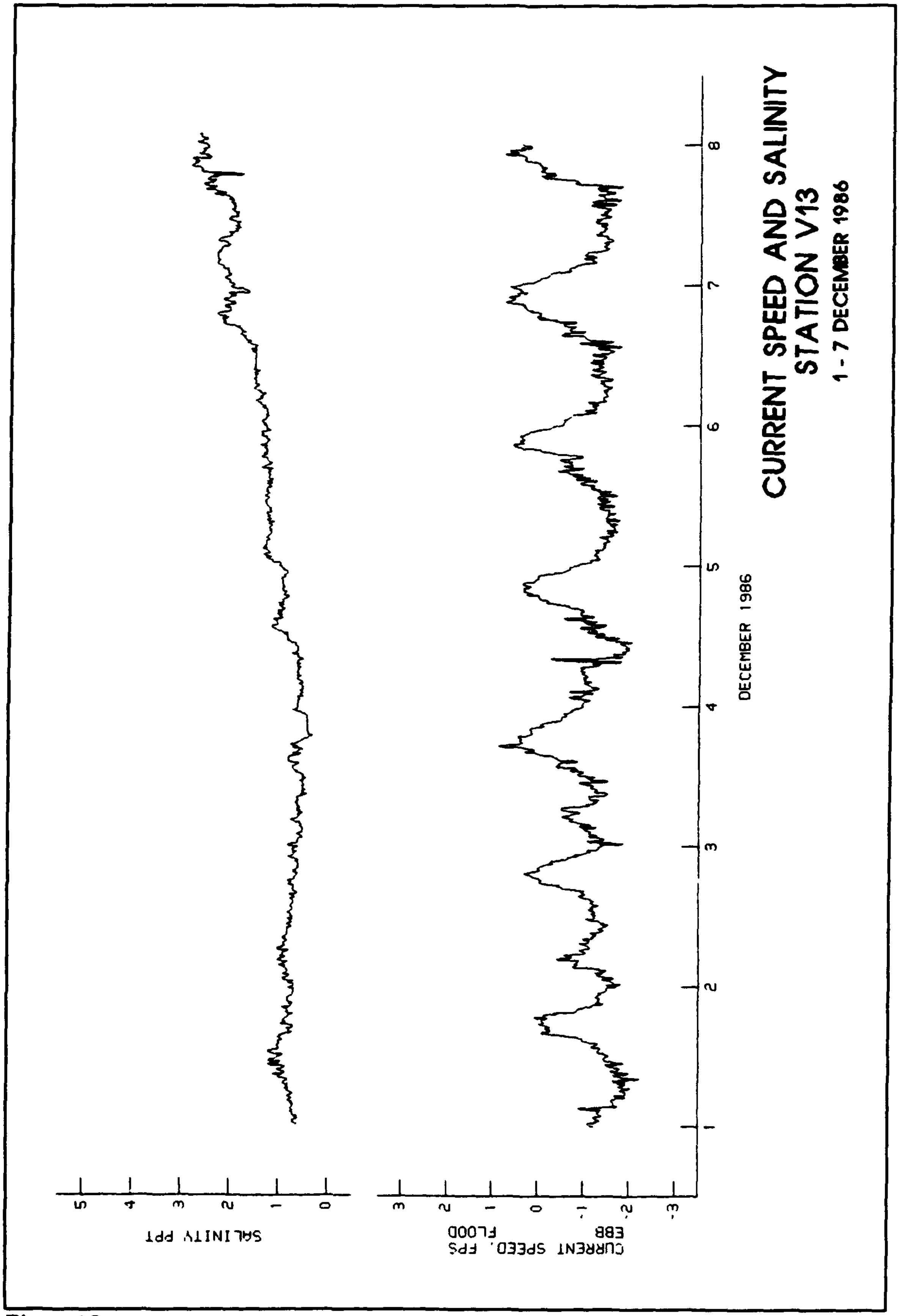
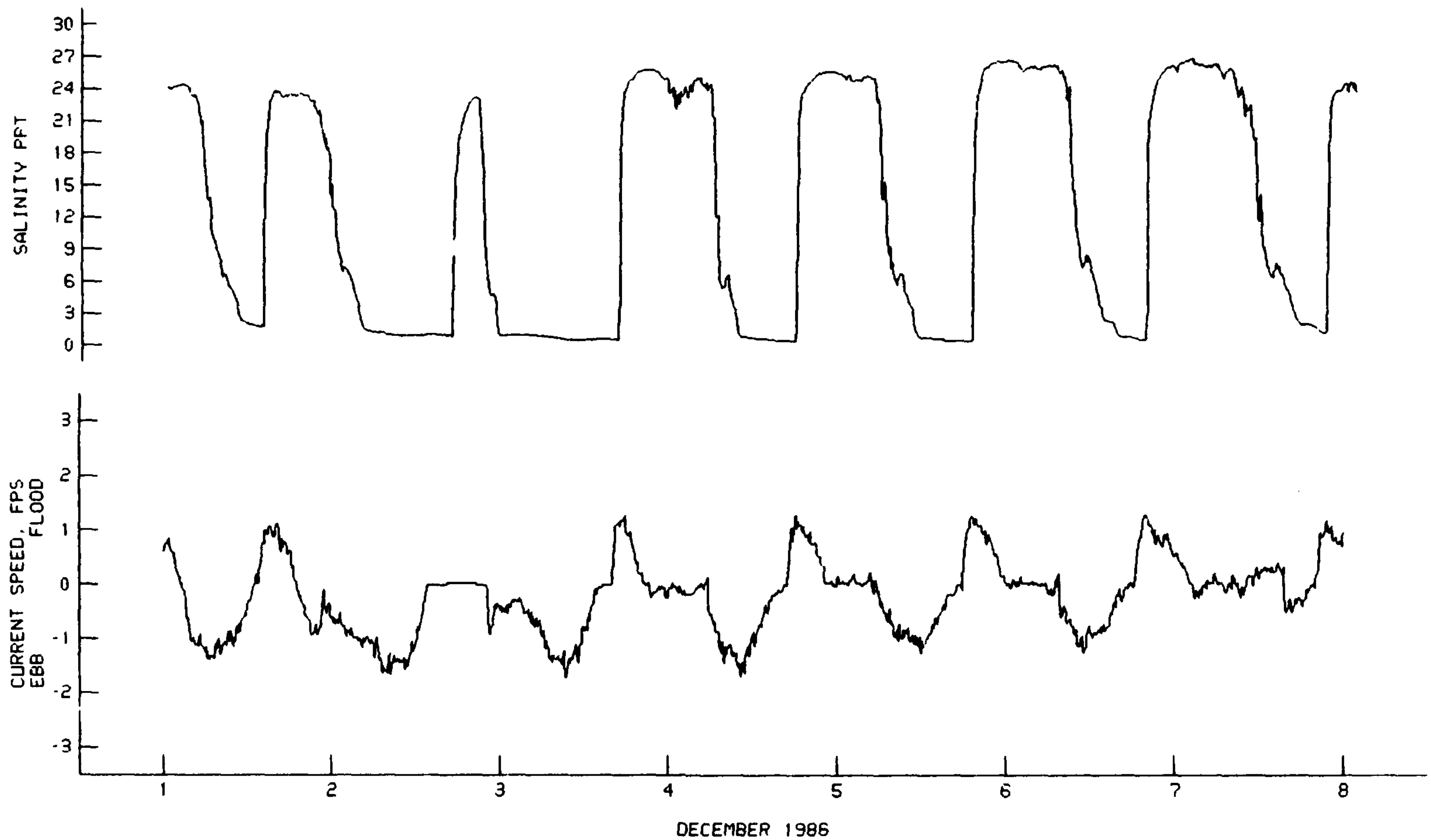
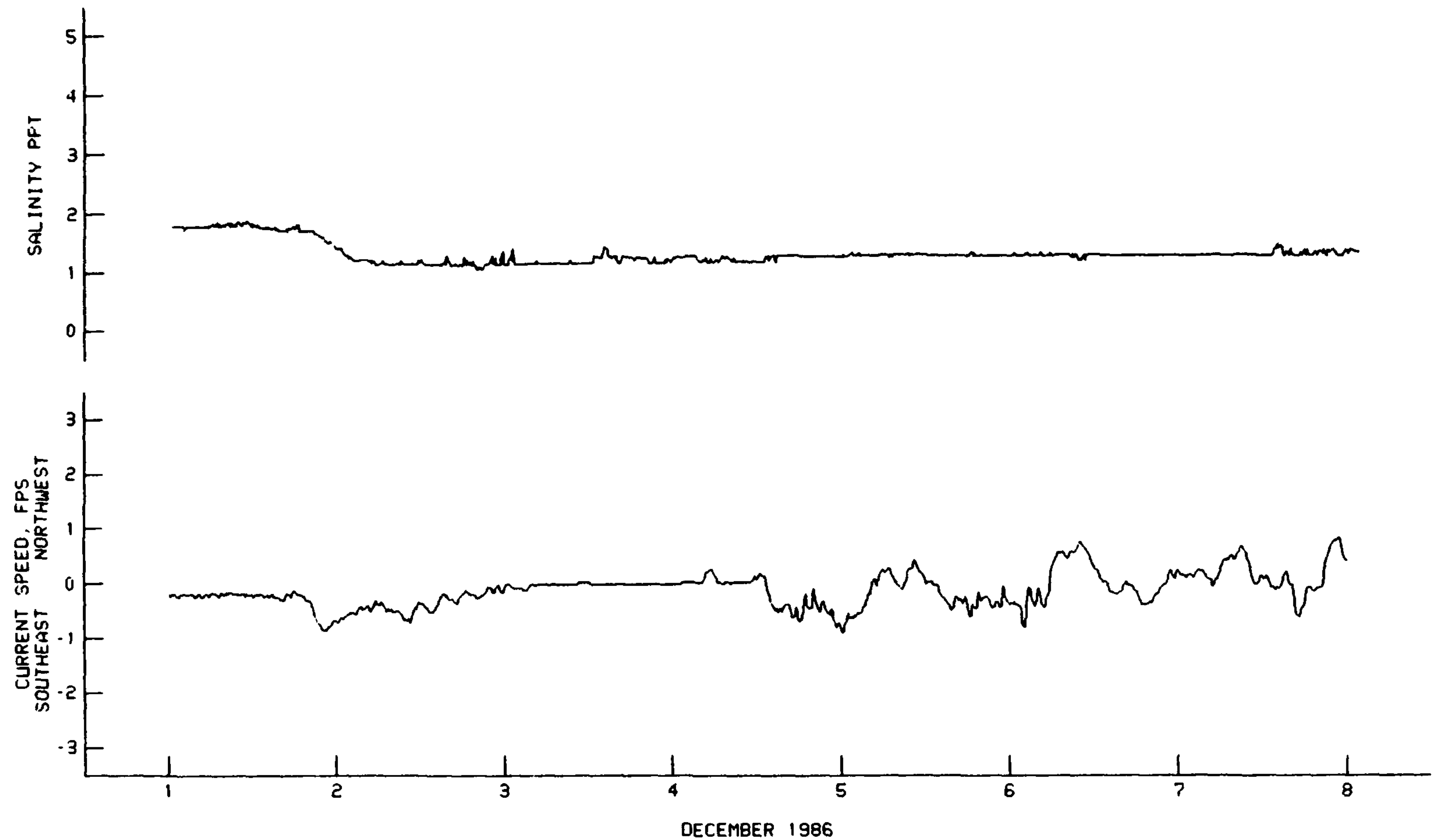

CURRENT SPEED AND SALINITY
STATION V13
1 - 7 DECEMBER 1986
SALINITY PPT
CURRENT SPEED, FPS
FLOOD
EBB
DECEMBER 1986
5
4
3
2
1
0
3
2
1
0
-1
-2
-3
1
2
3
4
5
6
7
8

Plate 12

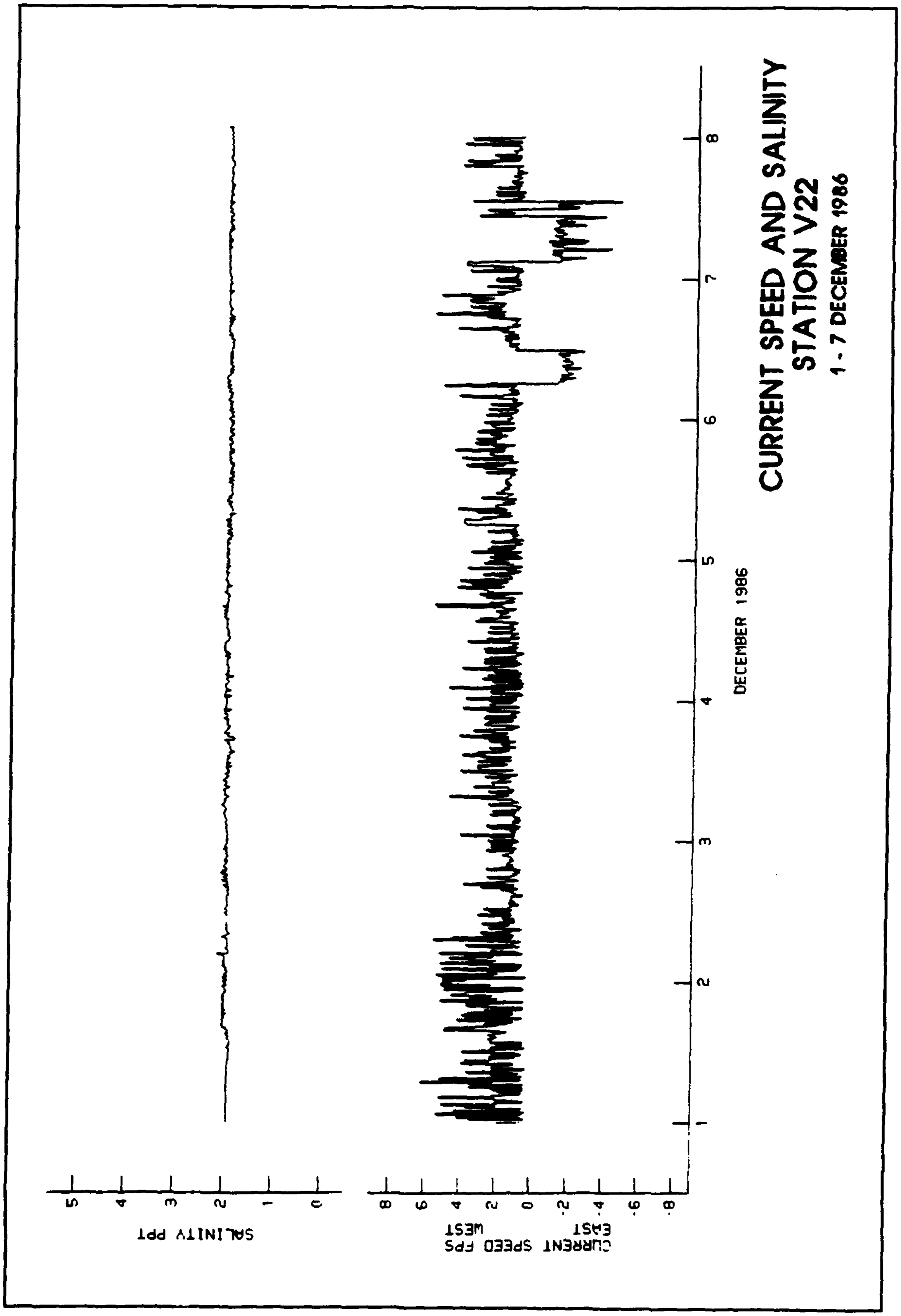


CURRENT SPEED AND SALINITY
STATION V16
1 - 7 DECEMBER 1986



CURRENT SPEED AND SALINITY
STATION V20
1 - 7 DECEMBER 1986

Plate 14


CURRENT SPEED AND SALINITY
STATION V22
1 - 7 DECEMBER 1986
DECEMBER 1986
SALINITY PPT
CURRENT SPEED FPS
WEST
EAST

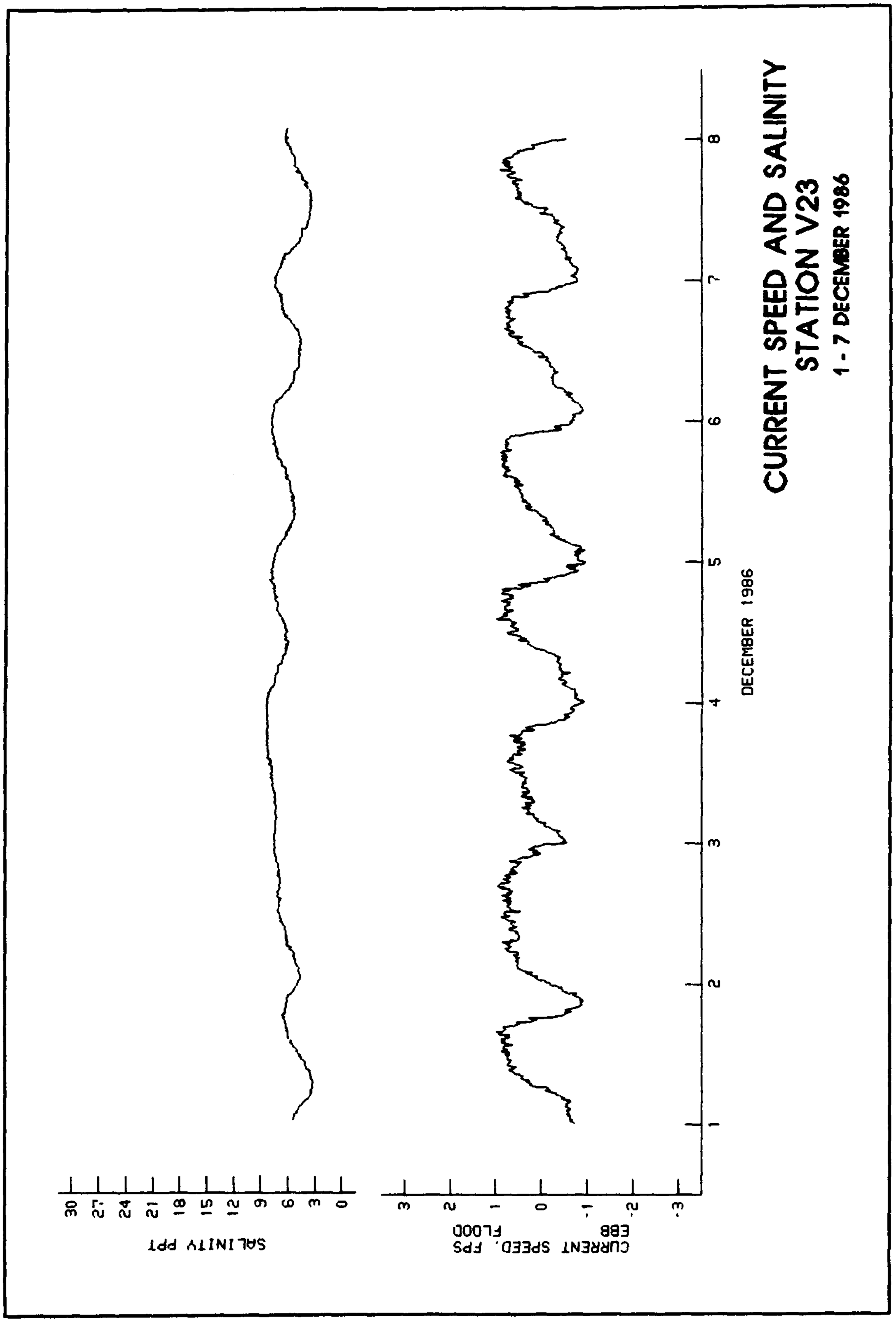
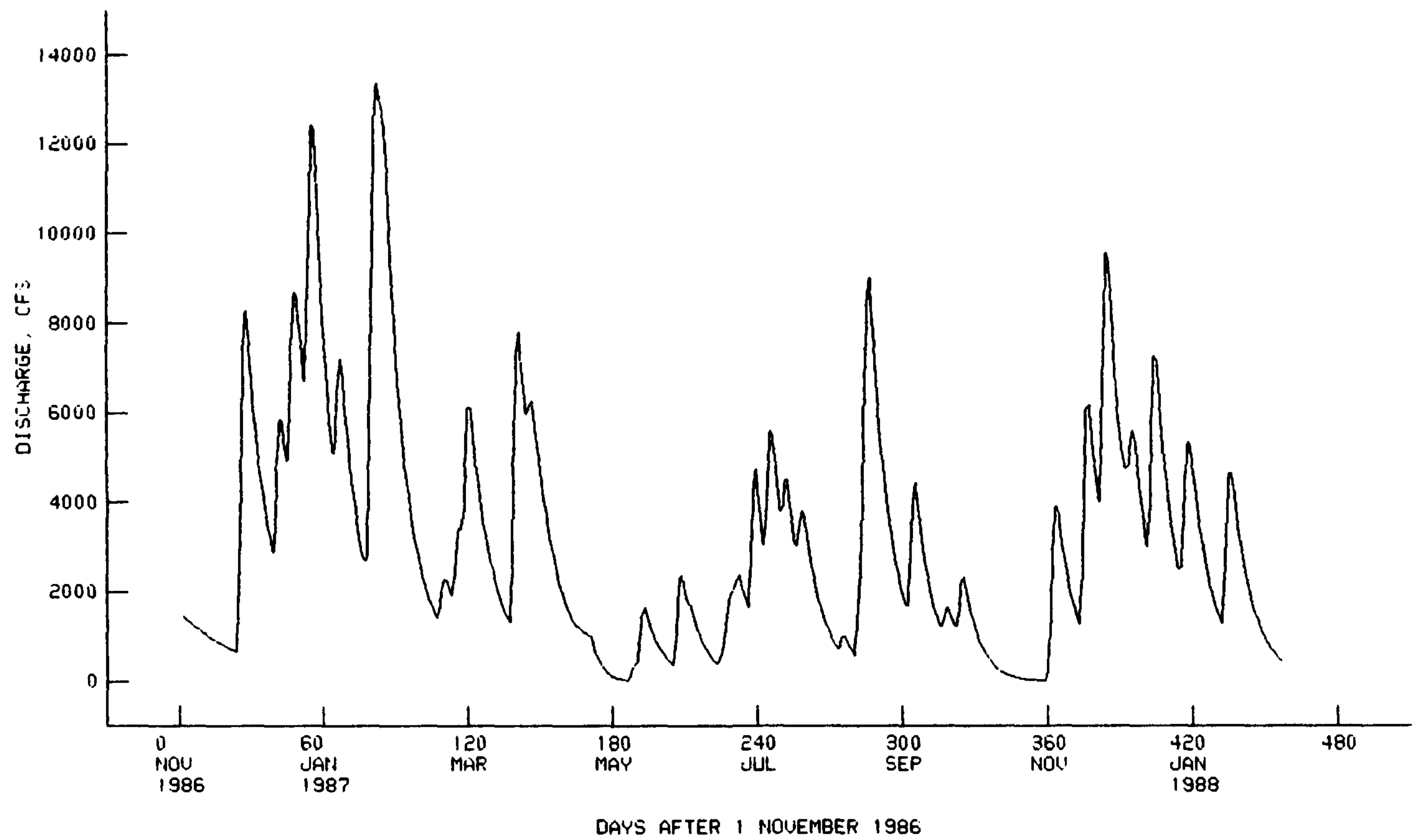

CURRENT SPEED AND SALINITY
STATION V23
1 - 7 DECEMBER 1986
SALINITY PPT
30
27
24
21
18
15
12
9
6
3
0
CURRENT SPEED, FPS
FLOOD
EBB
3
2
1
0
-1
-2
-3
1
2
3
4
5
6
7
8
DECEMBER 1986

Plate 16



MERMENTAU RIVER DISCHARGE

1 NOVEMBER 1986 - 31 JANUARY 1988

Appendix A
Estuarine Processes Branch Data Collection Equipment and Laboratory Analysis Procedures

The contents of this appendix are to provide detailed information on the types of data collection and laboratory equipment used in a majority of the field investigations performed by the Estuarine Processes Branch (EPB), Hydraulics Laboratory (HL), of the U.S. Army Engineer Waterways Experiment Station (USAEWES). The following table is provided to identify the parameters most commonly measured and the types of instruments which can provide these measurements.

Table A1

Current Velocity and Direction Measurements

Over-the-side current velocity and direction

Current velocity and direction measurements are obtained by deploying instruments over the side of a boat using a portable equipment setup shown in Figure A1. Collapsible aluminum frames are used to support the equipment, and winches (with 1/8-inch wire rope) are used to raise and lower the velocity and direction equipment. An indicator on the winch displays the depth of the instruments below the water surface. A Gurley Model 665 velocity meter with vertical-axis cup-type impeller and direct velocity read-out is used to measure the current speeds. These meters have a threshold speed of less than 0.2 fps and an accuracy of ±0.1 fps for velocities less than 1 fps and ±5% for velocities over 1 fps. Current directions are monitored with a magnetic directional indicator mounted above the velocity meter on a solid suspension bar. Accuracy of the direction indicators are ±10 deg at speeds greater than 0.5 fps, however strong wave action moving the boat can cause temporary errors greater than this. This entire assembly is connected to a streamlined lead weight that holds the sensors in a vertical position and orients them into the direction of the flow. The signal cables from each instrument are raised and lowered with the equipment and connect to the display units located on the deck of the boat. A more detailed display of the system is shown in Figure A2.

Recording velocity meters

Self-contained recording current meters are used to obtain current velocity and direction measurements for both profiling and for long-term fixed-depth deployment. The two types of equipment commonly utilized are the Environmental Devices Corporation (ENDECO) Type 174 SSM current meters as shown in Figure A3 and the InterOcean S-4 electromagnetic current meter shown in Figure A5.

The ENDECO 174 SSM meter is tethered to a stationary line or structure and floats in a horizontal position at the end of the tether (as shown in

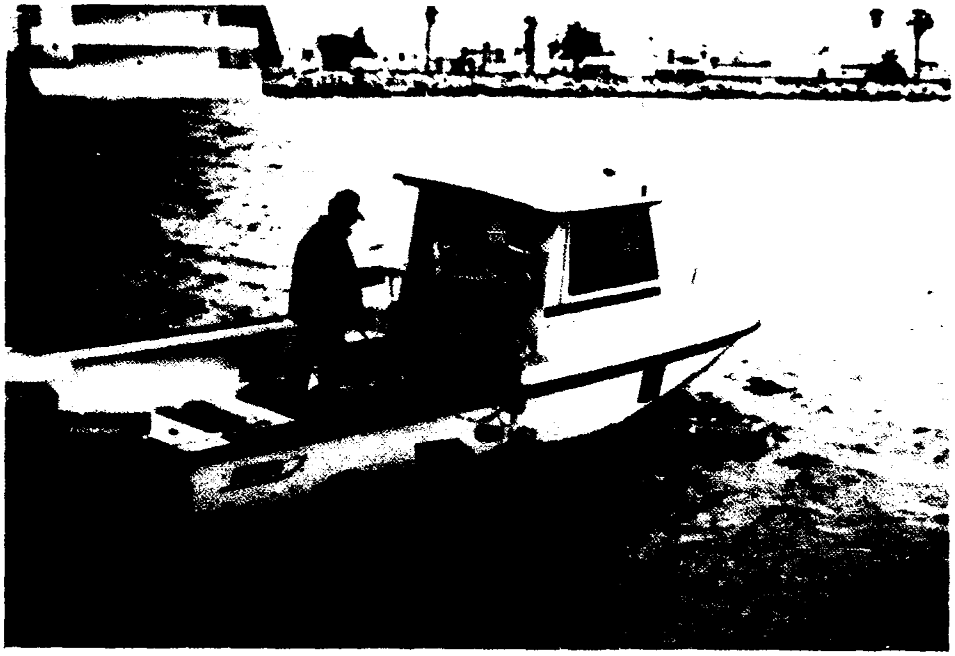


Figure A1. Field deployment of velocity measuring equipment

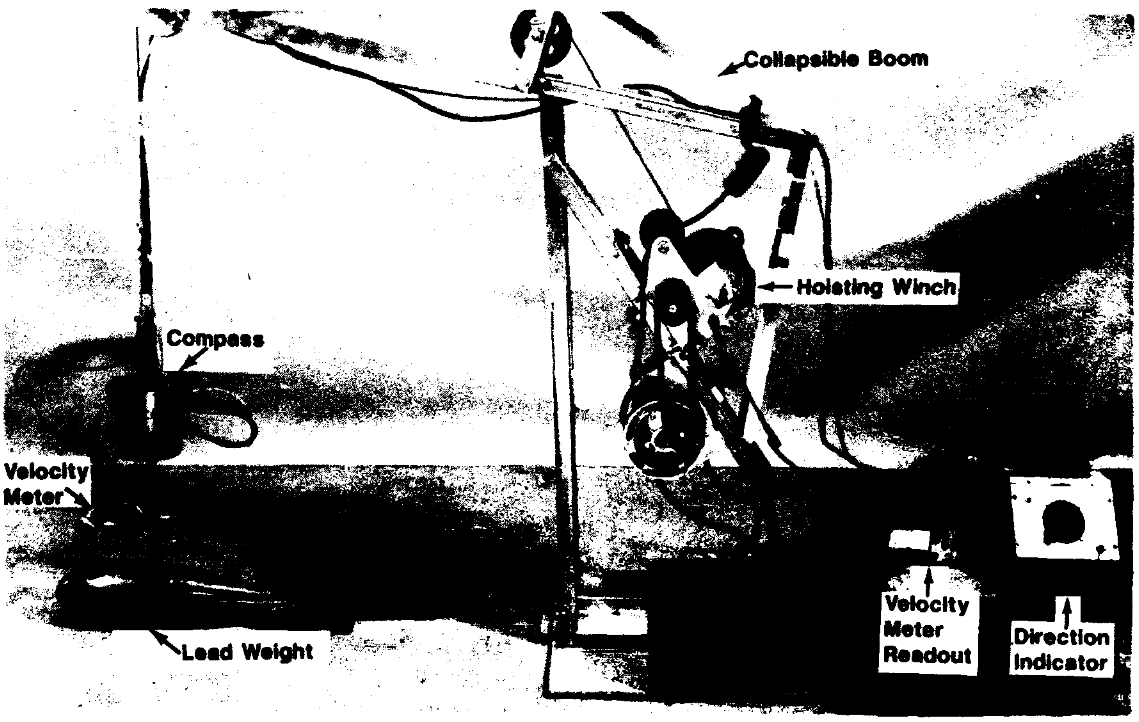


Figure A2. Components of the field instrument assembly

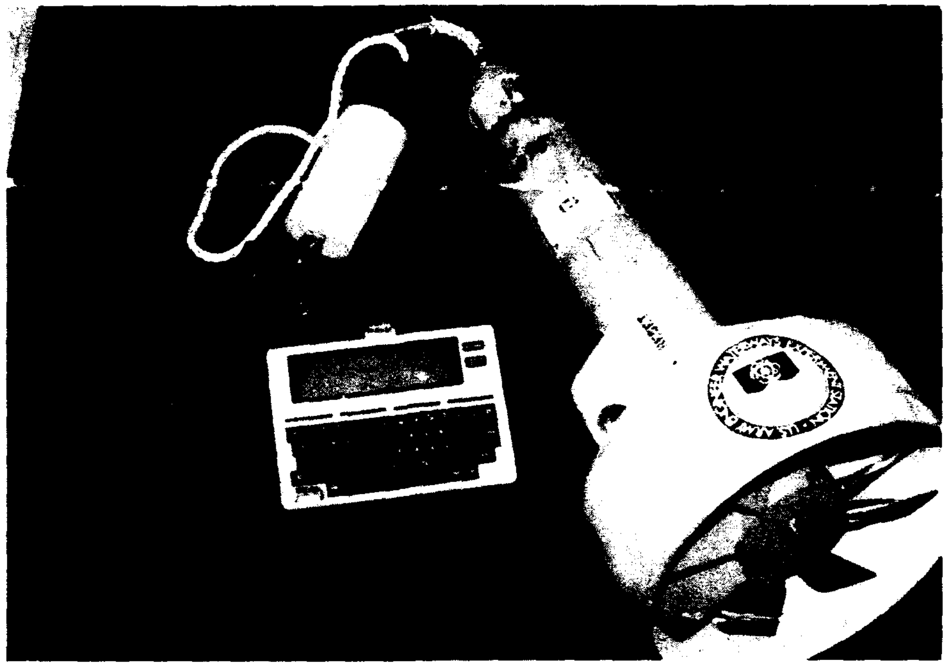


Figure A3. ENDECO 174 SSM recording current meter

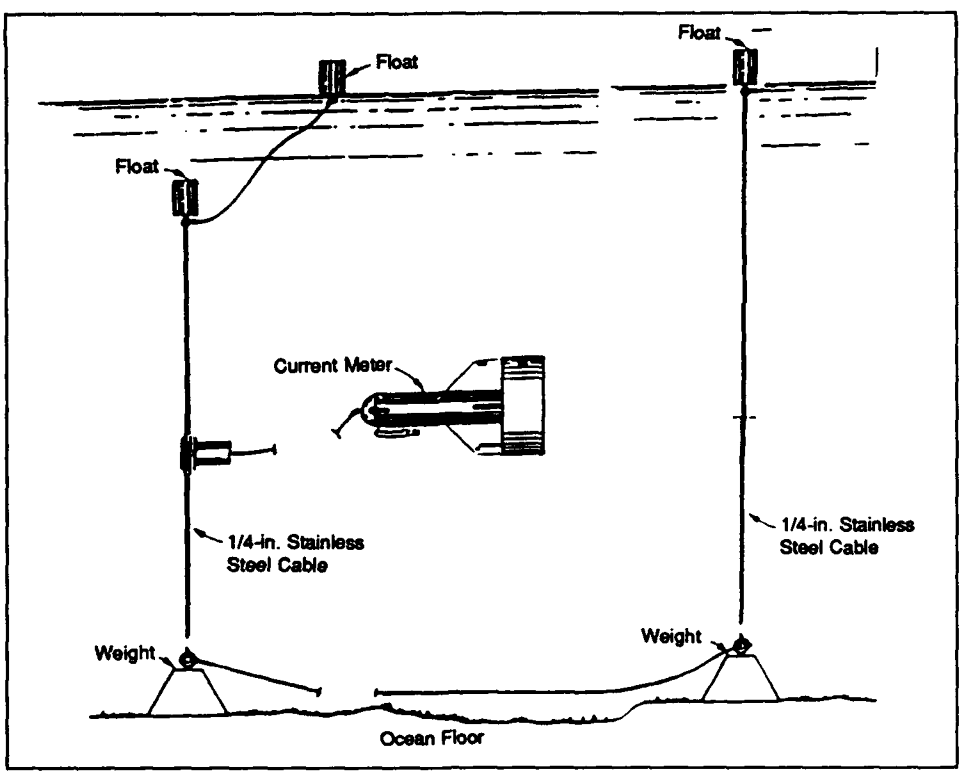


Figure A4. Typical deployment technique for fixed depth velocity measurements

Figure A4). It measures current speed with a ducted impeller and current direction with an internal compass. The ENDECO 174 SSM also measures temperature with a thermilinear thermistor and conductivity with an induction type probe. Data are recorded on an internal solid state memory datalogger. Data is offloaded from the meter datalogger by means of a communication cable connected between the meter and a computer. The threshold speed is less than 0.08 fps, maximum speed of the unit used is 8.44 fps (10 knots), and stated speed accuracy is ± 3 percent of full scale. The manufacturer states that direction accuracy is ± 7.2 deg above 0.08 fps. Time accuracy is ± 4 sec per day.

The InterOcean Model S-4 electromagnetic current meter can obtain continuous recording of current velocity and direction at fixed depths or can be used to profile the water column for current velocity and direction. The S-4 meter, shown in Figure A5, is a 10-inch diameter sphere that is suspended vertically in the water column with a submerged flotation device and anchored to the bottom by a heavy block and anchor arrangement. This deployment technique is illustrated in Figure A6. The S-4 meter measures the current velocity using an electromagnetic field to sense current induced by the movement of water through the field. An internal microprocessor coupled with an internal flux-gate compass computes the velocity vectors, which are then stored in the solid state memory. The accuracy of the S-4 meter current speed is ± 0.2 cm/sec.

Suspended Sediment Samples

Pumped water samples

In combination with the over-the-side velocity measuring equipment, water samples for analyses of salinities and total suspended solids are obtained by pumping the sample from the desired depth to the surface collection point. The pumping system consists of a 1/4-inch ID plastic tubing attached to the current meter signal cables for support. The opening of the sampling tubing is attached to the solid suspension bar at the same elevation as the current meter and is pointed into the flow. A 12-Vdc pump is used to pump the water through 50 ft of the tubing to the deck of the boat where each sample is then collected in individual 8-oz plastic bottles. The pump and tubing are flushed for approximately 1 min at each depth before collecting the sample.

Niskin sampler

The horizontal Niskin sampler, shown in Figure A7, is a hollow 3-inch diameter tube, 28 inches in length, with spring-loaded hinged caps on each end of the tube. The sampler is lowered, in a horizontal position, through the water column with the ends of the sampler open. When the sampler reaches the desired depth, a messenger (a weighted object) is released along the cable to trigger the closure of the ends trapping the desired volume of water within

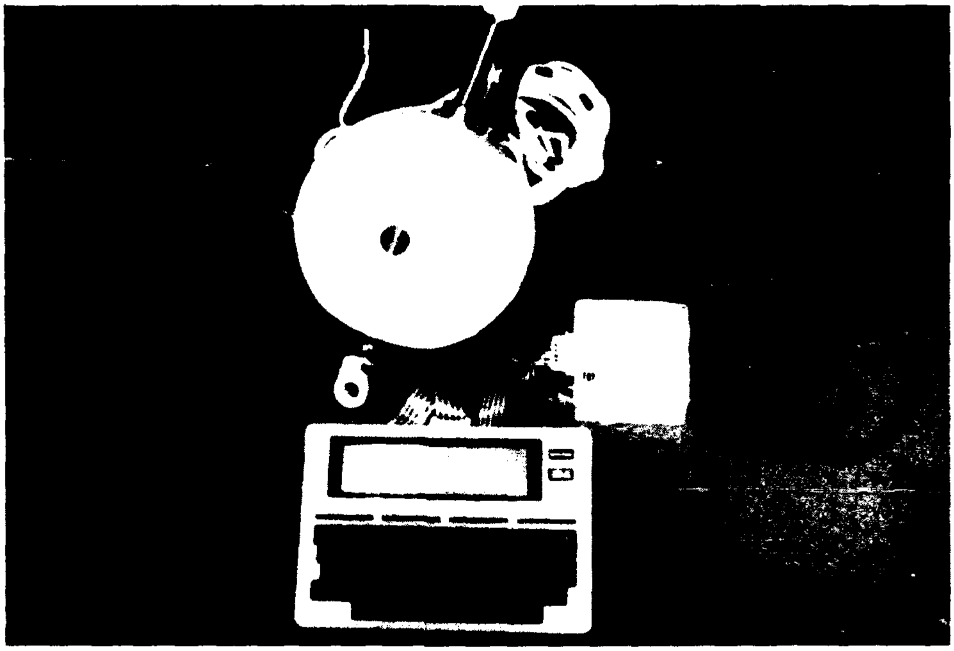


Figure A5. InterOceans S-4 current meter

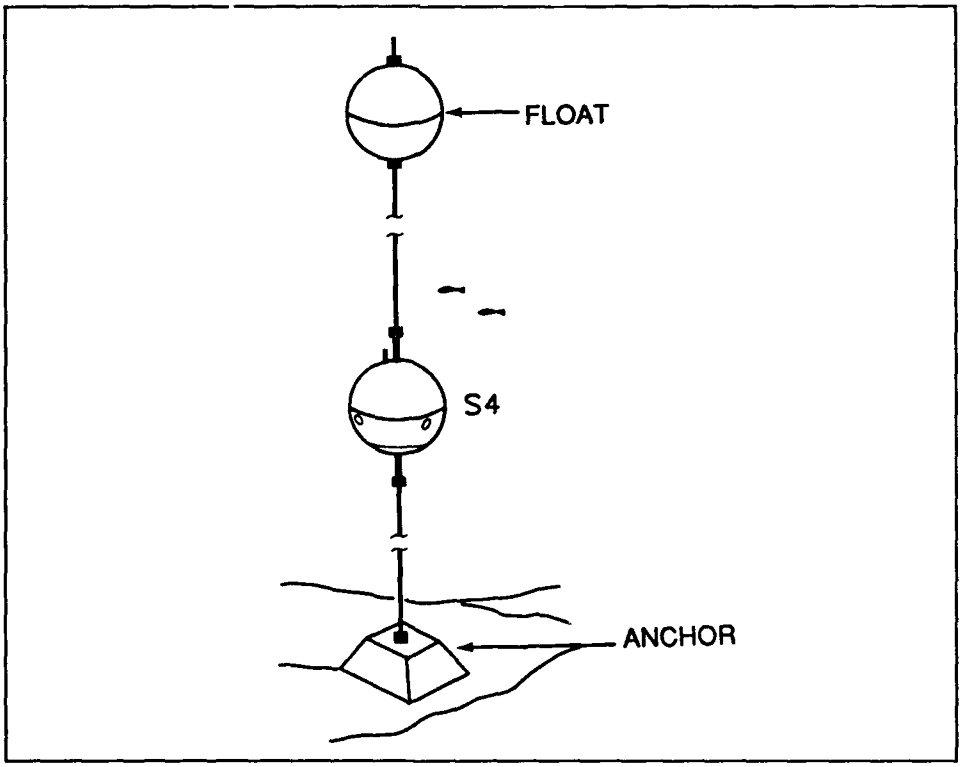


Figure A6. S-4 current meter deployment method

Figure A7. Niskin samplers

the sampler. It is then raised to the surface and the sample is removed and labeled. A small valve located on one end of the sampler is used to release the water sample. Multiple samples drained from the sampler at various times over a four hour period are used in the determination of settling velocities of suspended sediments within the sample. A log is maintained to include the sample number location, depth, time of sample removal, currents, and wave conditions. The samples are then placed in a rack for shipment back to the laboratory at WES for total suspended materials (TSM) and possibly salinity testing.

Automatic water samplers

The ISCO Model 2700 and American Sigma Model 700 automatic water samplers, shown in Figure A8, are employed to provide unattended sampling. A typical field installation of these water samplers is shown in Figure A9. Samples are collected in 1 liter plastic bottles located inside the sampler. The samplers are fully programmable, operating from a 12-Vdc power source, for obtaining any volume of sample desired up to the maximum size of the bottle, for obtaining composite samples, for setting different intervals between samples, and for setting times to begin the sampling routine. During servicing, the sample bottles are replaced with empty bottles to begin a new sampling period.

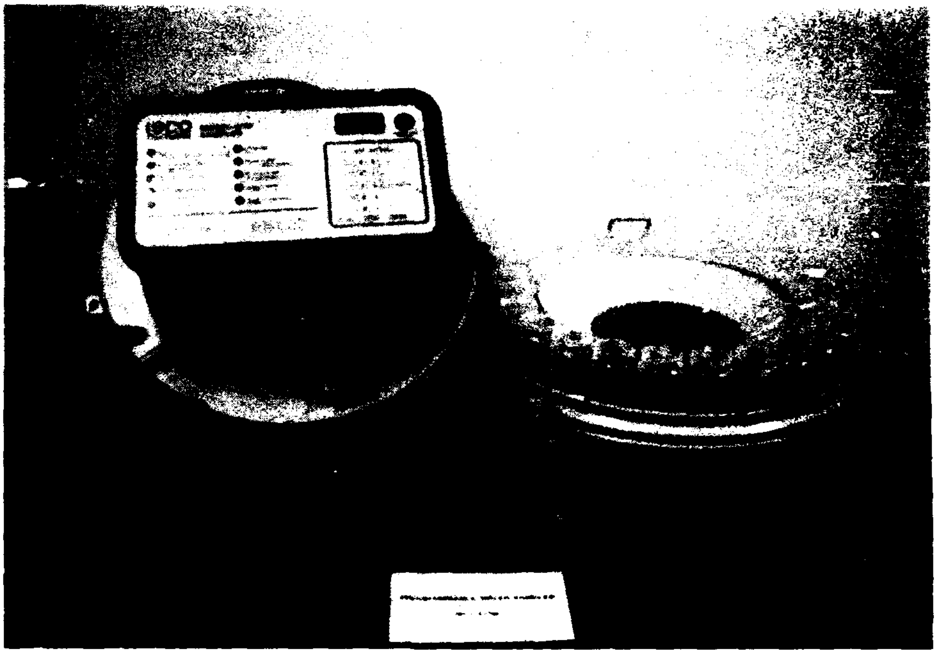


Figure A8. Automatic water sampler

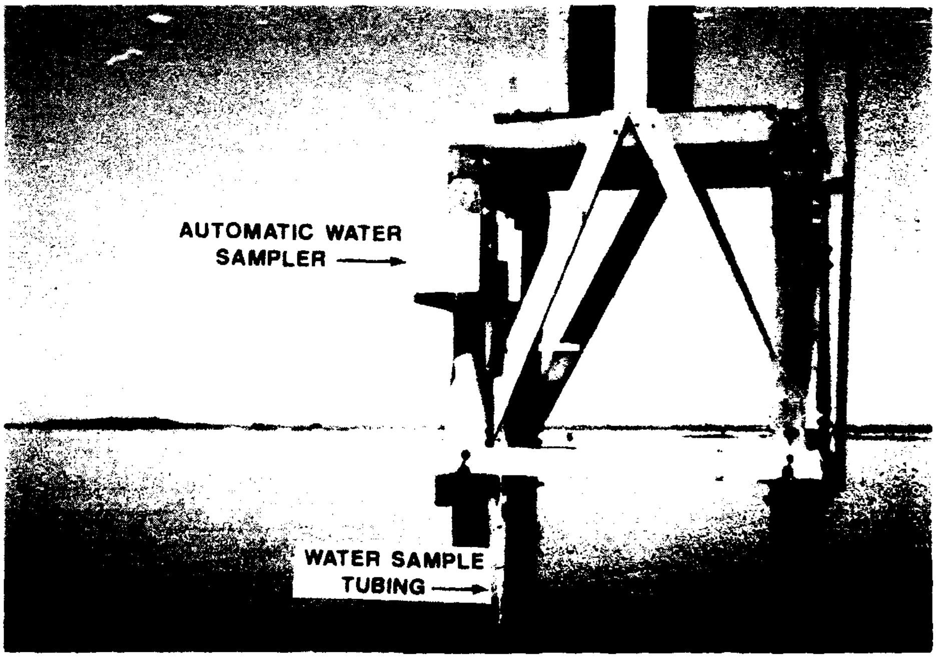


Figure A9. Typical field installation of the automatic water samplers

Water Level Measurements

Mechanical punch tape recorders

Water level measurements are made by a system consisting of a stilling well-contained float connected to a recording device by a wire rope. The recorders used are Fischer and Porter Company model 1550 punched tape mechanical water level recorders similar to the one shown in Figure A10. These instruments record elevations to the nearest 0.01 ft and have a range of up to 100 ft. A timer activates the recording mechanism every 15 min, and the float elevation at the time is punched on 16-channel, foil-backed paper tape. The float is a 3-in-diameter aluminum cylinder, and the stilling well is a vertical 4-in-diameter PVC pipe. A typical field installation is shown in Figure A11. Water in the stilling well responds to water levels outside the well by flow through a 15-ft long, 3/8-inch-diameter copper tube. The outer end of the tube is protected against clogging by means of a cylindrical copper filter.

The 15-ft-long copper tubing used as the stilling well filling port is designed to minimize short-period oscillations and to cause the well to respond linearly to fluctuations in the outside water level. Response characteristics of the stilling wells have been determined by drainage tests.[1] Initial synchronization of the tide recorder timer is within ±5 sec of the National Bureau of Standards (NBS) time standard. The gage time is generally accurate to ±2 min per month, except for occasional malfunctions that can cause large time errors. In practice, recorder and NBS times are recorded when tapes are removed so that timing errors can be identified. The relative accuracy of the water level recorders is affected by temperature of the water, float and wire, plus salinity changes of the water inside the well. Relative accuracy is considered to be within 0.1 ft.

Electronic water level recorders

Water level elevation measurements can also be recorded using solid state electronic recorders, such as Microtide and ENDECO water level recorders.

The Microtide water level recorders, shown in Figure A12, contain a strain gage type pressure transducer in a subsurface case which records the absolute pressure of the column of water above the case. The pressure transducer is not vented to the atmosphere, therefore an extra unit is positioned in the study area to record atmospheric pressure changes. Water pressure is measured for the desired sample interval and an average value is computed and stored on the

[1] W. H. McAnally, Jr. (1979). "Water level measuring by Estuaries Division, Hydraulics Laboratory," Memorandum for Record, US Army Engineer Waterways Experiment Station, Vicksburg, Ms.

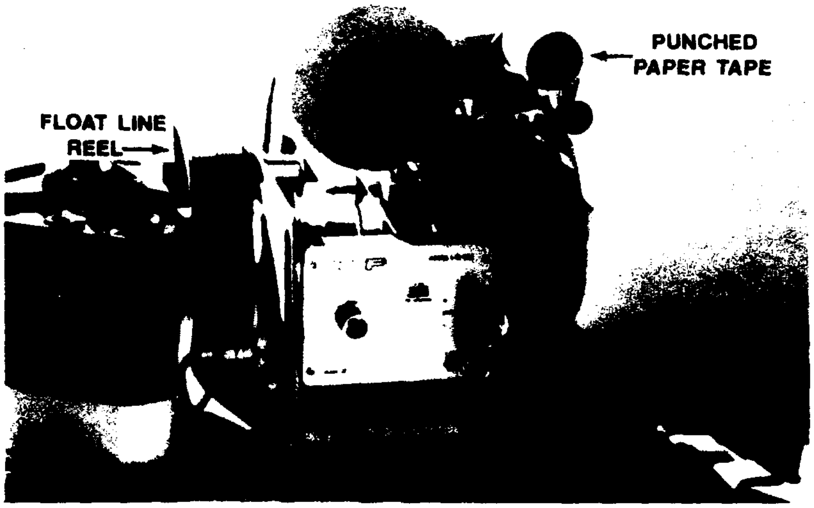


Figure A10. Punched paper mechanical water level recorders

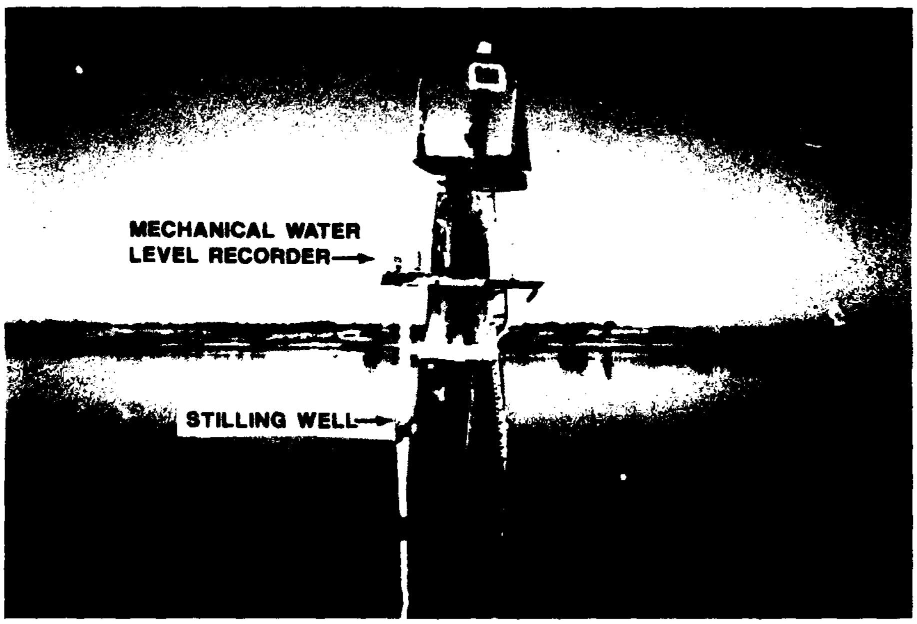


Figure A11. Typical field installation of mechanical water level recorders

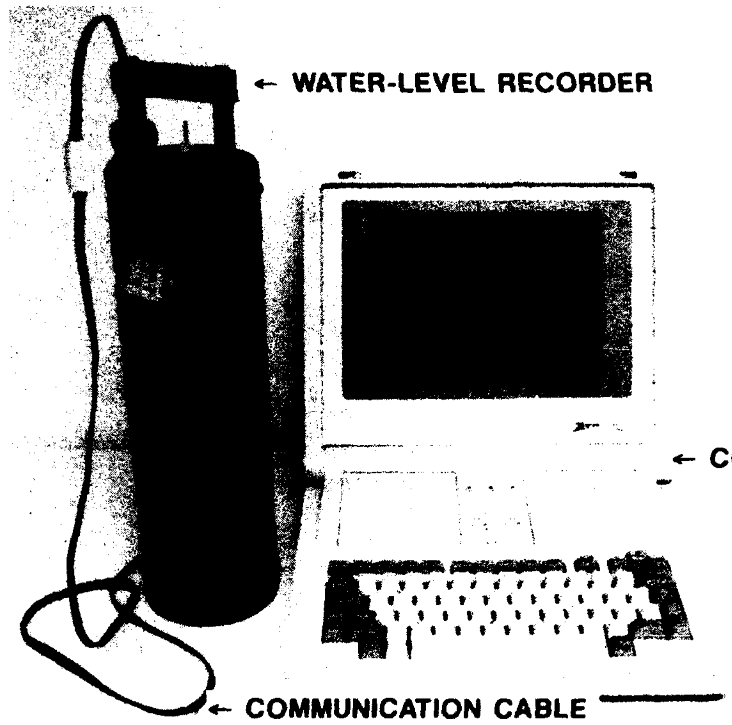


Figure A12. Microtide electronic water level recorder

internal RAM data logger. The stated accuracy is ±0.02 ft. The sampling time interval can be set from 1 minute to 24 hours. The Microtide also measures temperature by means of a YSI thermilinear thermistor built into the water level recorder. The thermistor has a range of -5°C to +45°C, with a stated accuracy of ±0.1°C. The data from each recorder is stored on an accessible RAM located in the waterproof subsurface unit which also contains the DC power supply.

Water level elevations, temperature, conductivity, and salinity measurements, are recorded using Environmental Devices Corporation (ENDECO) models 1152 and 1029 (water level and temperature only) solid state measurement (SSM) water level recorders shown in Figure A13. The ENDECO model 1152 SSM and 1029 SSM recorders contain a strain gage type pressure transducer located in a subsurface case which records the absolute pressure of the column of water above the case. The pressure transducer is vented to the atmosphere by a small tube in the signal cable to compensate for atmospheric pressure. The pressure is measured for 49 seconds of each minute of the recording interval with a frequency of 5-55 KHz to filter out surface waves, therefore eliminating the need for a stilling well. The accuracy is ±0.05 ft. The sampling time interval can be set from 1 minute to 1 hour. The 1152 SSM and 1029 SSM also measure temperatures by means of a thermilinear thermistor built into the recorders. The thermistor has a range of -5°C to +45°C, with an accuracy of ±0.2°C. The 1152 SSM measures conductivity

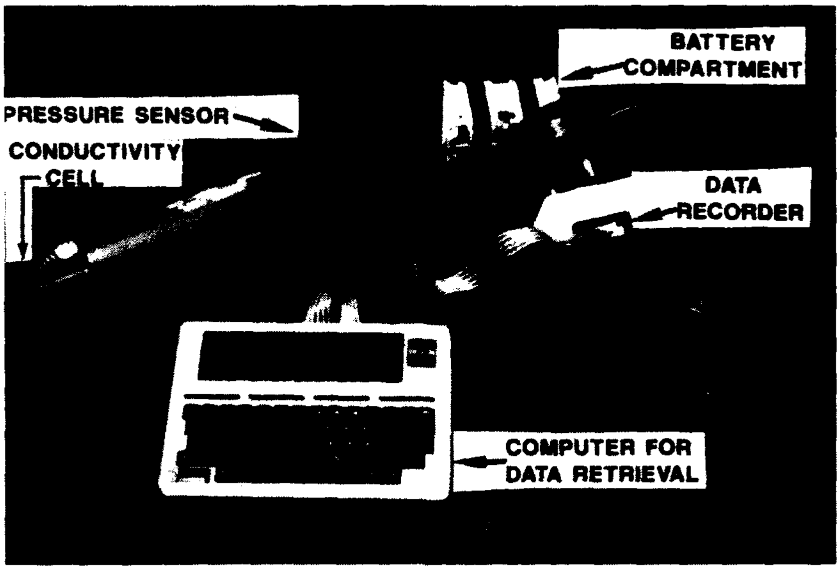


Figure A13. Water level recorder

by an inductively coupled probe installed on the meter. These measurements and the measurements of temperature are used to calculate water salinity in units of parts per thousand (ppt) with an accuracy of $\pm$0.2 ppt.

The sampling time interval for conductivity and temperature cannot be set independently from the water level measurements. The data from each recorder is stored on a removable EPROM solid state memory cartridge located in a waterproof surface unit which also contains the DC power supply.

Salinity Measurements

Aanderaa salinity recorder

The Aanderaa RCM4 Salinity Recorder, shown in Figure A14, provides conductivity and temperature measurements required to calculate water salinity at a fixed depth. The recorder housing is an aluminum alloy case with anodized external conductivity cell and temperature sensors to minimize corrosion. The recorder has a range of 0 to 40 ppt with an accuracy of $\pm$0.2 ppt. The data are recorded on a 1/4-inch magnetic tape in 10-bit binary word serial format. The data sampling intervals range from 1-180 minutes with an accuracy of $\pm$0.5 sec/day. The magnetic reels are removed from the recorders and returned to WES for processing using a tape reader.

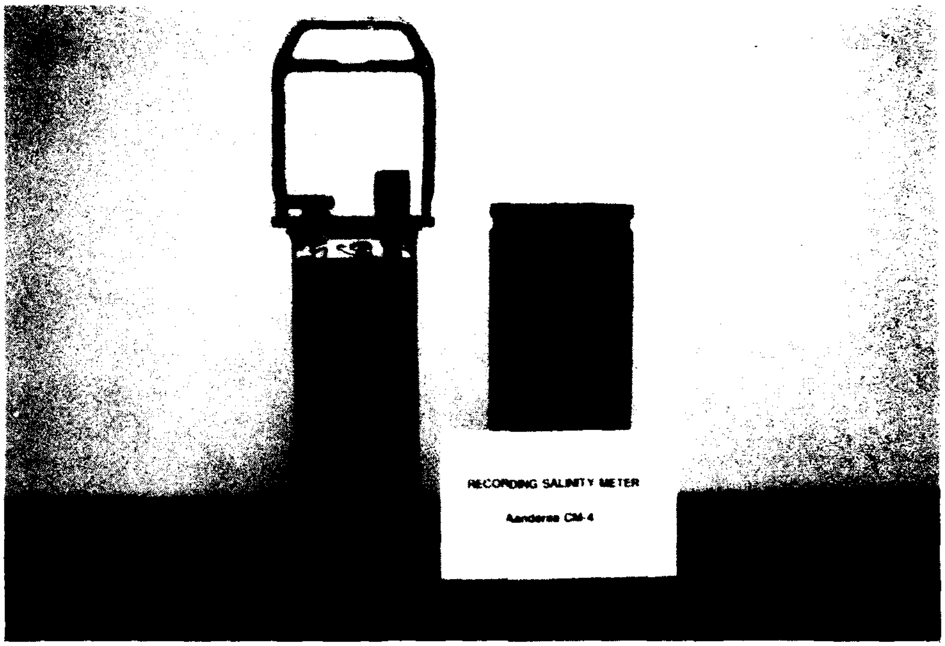


Figure A14. Aanderaa salinity recorder

Bottom Sediment Sampling

Push core sampler

Bottom sediment are obtained using a push core type sampler. The sampler consists of a 1-1/2-inch-diameter PVC pipe, 18 inches in length. Attached to this is a smaller section of pipe with a valve attached at the upper end. The purpose of the valve is to create a reduced pressure holding the sample in the larger diameter pipe. The samples are then brought to the surface and classified by visual inspection or transported back to WES for more detailed analysis.

USGS BM-54 bottom sampler

The BM-54 sampler, shown in Figures A15 and A16, is a 100 lb sampler use to collect samples from the bed of a stream, reservoir, or estuary of any depth. The sampler is made of cast iron, 22 inches long, equipped with tail fins and a spring loaded scoop-type sampling bucket located on the bottom of the sampler. The sampler is supported by a steel cable from a portable winch and boom system. The scooping sampling bucket is cocked and spring loaded in the open position while being supported by the steel cable and winch. Lowering the sampler to the bottom, the tension on the cable is released when the sampler rests on the bottom, the bucket snaps shut taking the sample. The sample is collected from the top 2 inches of the bottom material. The bucket

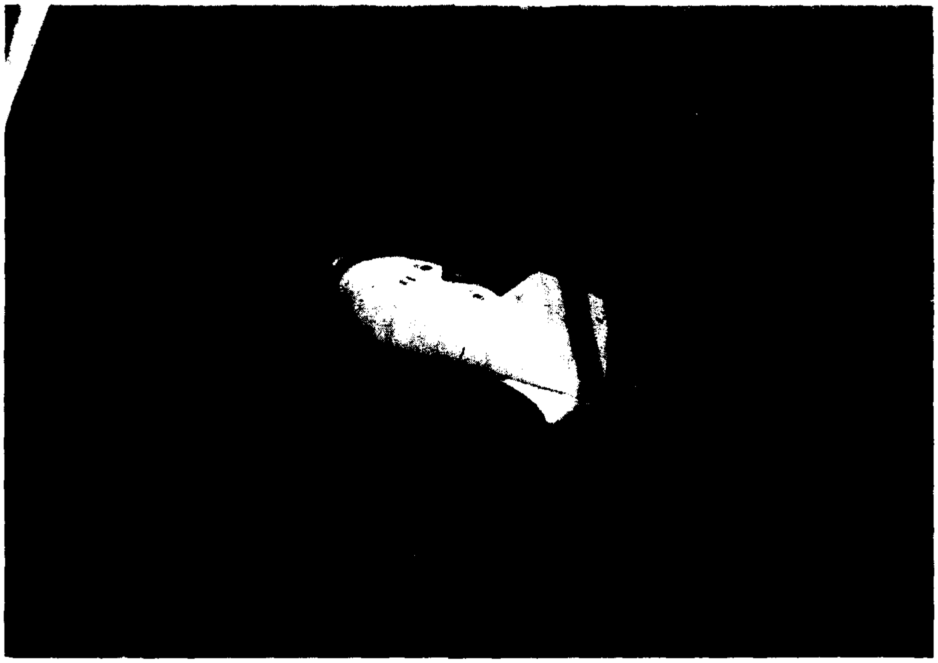


Figure A15. Bed material sampler US BM-54 being deployed from boat

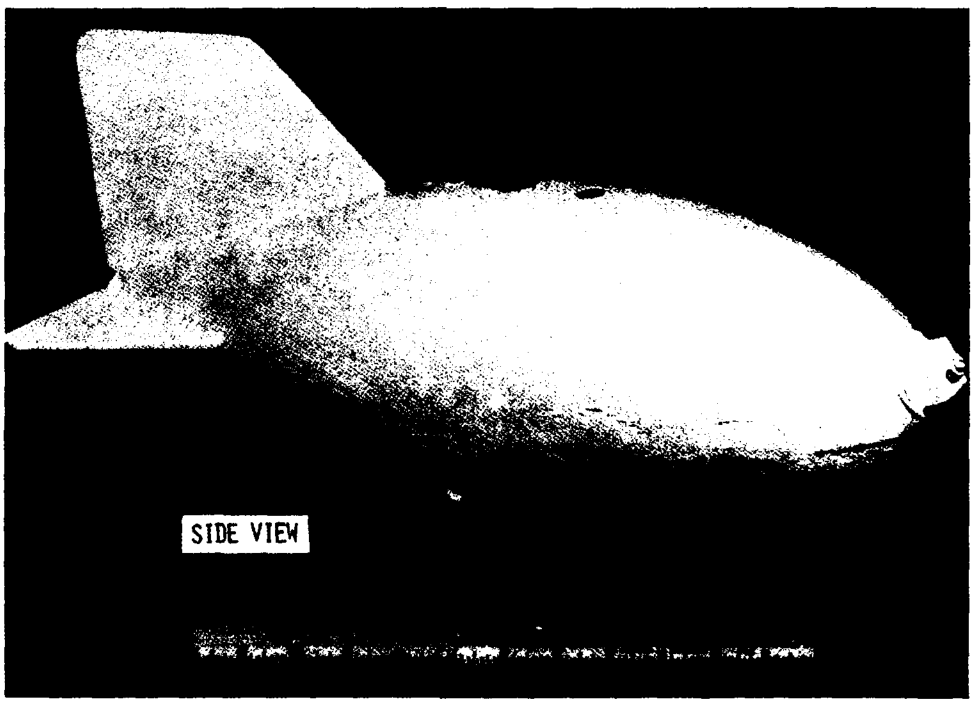


Figure A16. Bed-material sampler, US BM-54

surrounds the sample and prevents it from being washed out as it is raised to the surface.

Meteorological Measurements

Hand-held wind speed and direction indicators

Wind speeds are recorded using a WeatherMaster Model No. 132 hand-held anemometer. The anemometer is oriented into the direction of the prevailing wind and the maximum reading on the analog scale is observed and recorded. The directions of the prevailing winds are determined from compass heading of the anemometer giving the highest speed indication.

Digital data recording station

Continuous wind speed and direction measurements are recorded using a HANDAR Model No. 540-A Data Acquisition system (see Figure A17). The data collection platform is typically located at some central location in the study area and mounted approximately 10 meters above the water. The data acquisition system is a battery-powered microcomputer with a real-time clock, a serial data interface, and programmable analog to digital converter. The battery is constantly charged using a solar panel charging system located near the system. Various programming options are available for setting the sampling interval of the system for the input signals from the wind speed and direction sensors. The system can be programmed to sample the input signals each second over a set period of time to determine the mean wind speed, mean direction, maximum wind gust speed, and maximum wind gust direction. The data is processed internally and stored in formats specified in a user-entered output table. The accuracy of the analog input of the wind speed and direction sensors are $\pm$1.0 mph and $\pm$3.0 deg, respectively.

Laboratory Equipment and Sample Analysis

Laboratory analysis for salinities

An AGE Instruments Incorporated Model 2100 MINISAL salinometer (Figure A18) with automatic temperature compensation is used for the determination of salinity concentrations in the individual samples. The salinometer is a fully automated system, calibrated with standard seawater, and the stated manufacturers accuracy is $\pm$0.003 ppt on samples ranging from 2 to 42 ppt.

Laboratory analysis for total suspended materials

Total suspended materials (TSM) are determined by filtration of samples.

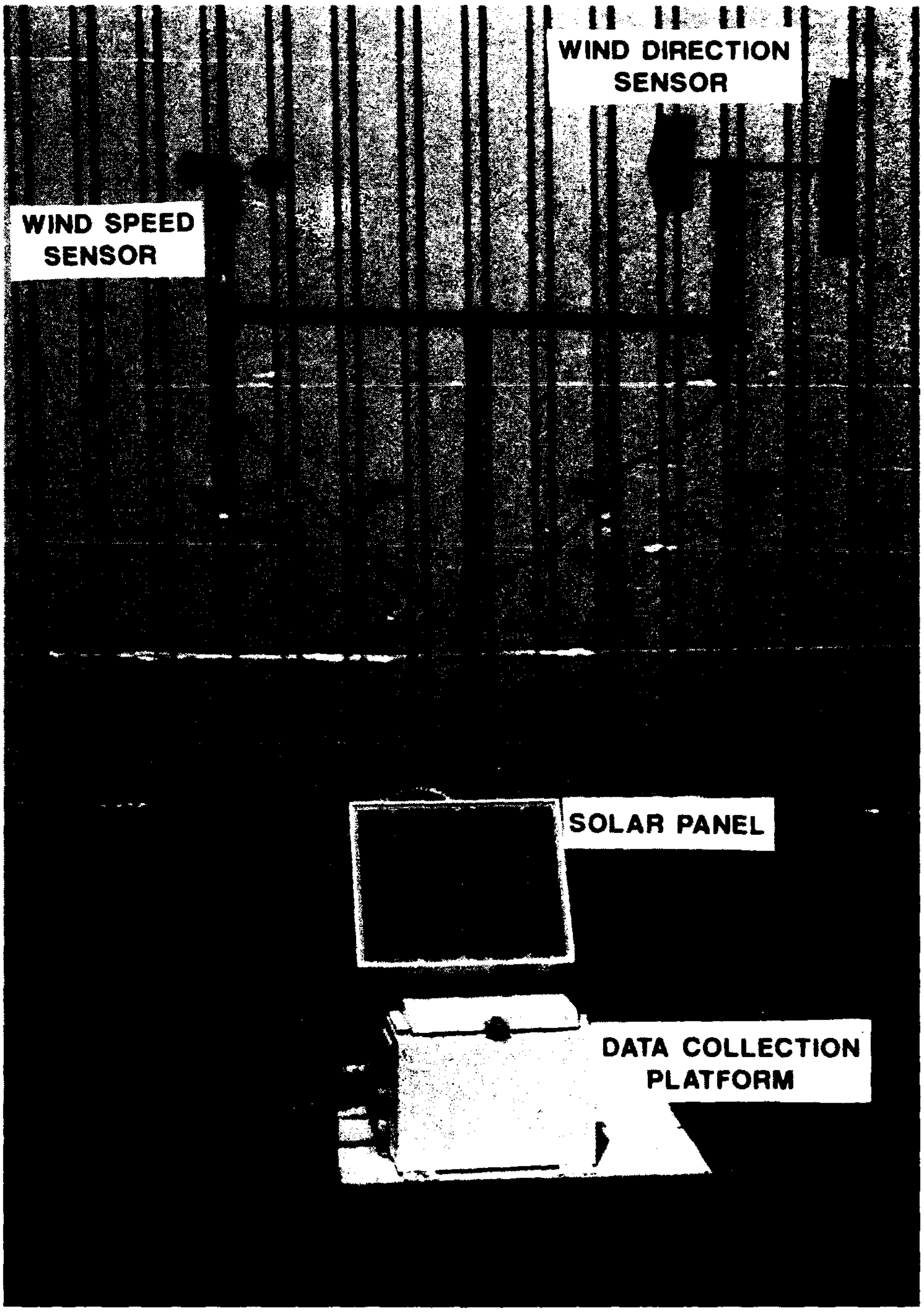


Figure A17. HANDAR meteorological data acquisition system

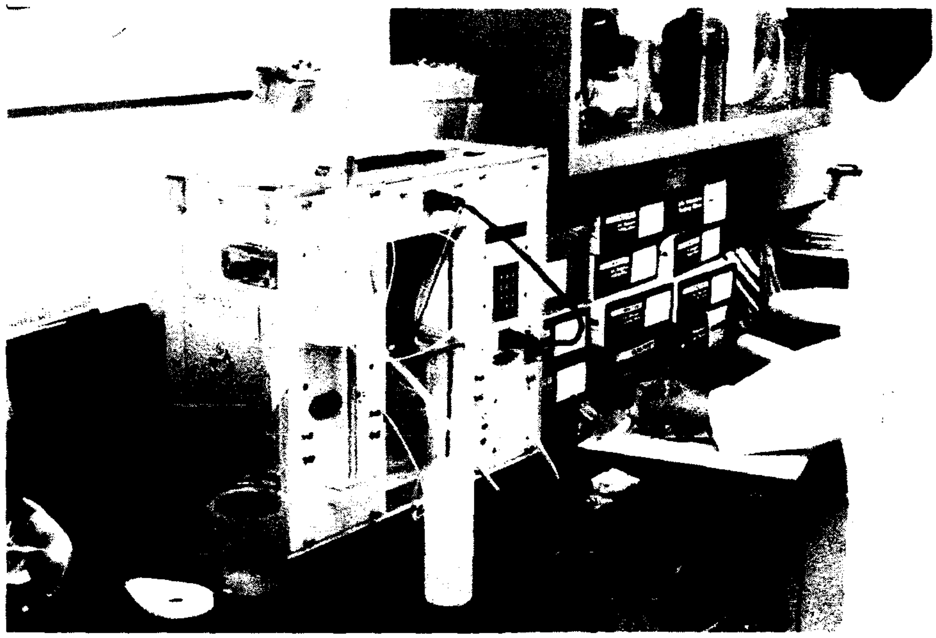


Figure A18. AGE MINISAL salinometer

tare wt = tare weight of pycnometer

vol pyc = volume of pycnometer

sed + water wt = weight of pycnometer with sediment and water

Nuclepore (Registered Trademark) polycarbonate filters with 0.40 micron pore size are used. They are desiccated and preweighed, then a vacuum system (8-lb vacuum maximum) is used to draw the sample through the filter. After the filters and holders are washed with distilled water, the filters are dried at 105°C for 1 hr and reweighed. The TSM are calculated based on the weight of the filter and the volume of the filtered sample.

Density analysis

A density analysis is done using wide-mouth, 25-cm constant-volume pycnometers. They are calibrated for tare weight and volume. A pycnometer is partially filled with sediment and weighed, then topped off with distilled water. Care is taken to remove any bubbles before the pycnometer is reweighed. The bulk density (BSG) of the sediment is then calculated by the equation:

$$BSG = \frac{(p)\ (sed\ wt\ -\ tare\ wt)}{(p)\ (vol\ pyc)\ +\ (sed\ wt)\ -\ (sed\ +\ water\ wt)}$$

where;

p = density of water at temperature of analysis
sed wt = weight of pycnometer with sediment
tare wt = tare weight of pycnometer
vol pyc = volume of pycnometer
sed + water wt = weight of pycnometer with sediment and water

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** July 1993	**3. REPORT TYPE AND DATES COVERED** Final report

4. TITLE AND SUBTITLE

Data Collection for Grand and White Lakes, Louisiana

5. FUNDING NUMBERS

6. AUTHOR(S)

Howard A. Benson
Clara J. Coleman
Joseph W. Parman

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

Miscellaneous Paper HL-93-3

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Engineer District, New Orleans
P. O. Box 60267
New Orleans, LA 70160-0267

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Grand and White Lakes area covers approximately 2,000 square miles in southwest Louisiana and is rich in natural resources: oil, gas, fish, shrimp, wildlife, and fowl. Groups with widely divergent interests-farmers, cattlemen, fishermen, shrimpers, hunters, trappers, navigation interests, and wildlife interests-all use the area. Each of these groups has different and often conflicting water use requirements. The Corps' concern is to select a water management plan that will make the greatest contribution to the national economic development consistent with protecting the environment. The study documents the data collected for use in development and verification of numerical models to predict effects of several alternative plans on water levels, circulation, and salinity intrusion in the Grand and White Lakes area. The report presents representative results of the data collection program in this area from November 1986 through December 1987 and describes the equipment and procedures used in the data acquisition.

14. SUBJECT TERMS

Grand Lake	Prototype data acquisition
Mermentau River Basin	Salinity intrusion
Numerical model predictions	White Lake

15. NUMBER OF PAGES 61

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
UNCLASSIFIED	UNCLASSIFIED		